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INSTITUTE OF ENGINEERS.

TRANSACTIONS.

VOL. X.

1876 and 1877.

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LIST OF MEMBERS.

MARCH 1878.

A.

Date of Election.

1857 ADAMS, WILLIAM (*Past President*), Assoc. Inst. C.E., F.G S., Civil and Mining Engineer, Cardiff

1868 ADAMS, G. F. (*Member of Council*), F.G.S. M. Inst. C.E., Civil and Mining Engineer, Cardiff

1870 Abraham, David, Surveyor, Bargoed, near Cardiff

1876 Armstrong, Wm. Lamb, M.E., Dunraven Collieries, Treherbert.

B.

1857 BASSETT, ALEXANDER (*Past President*), M. Inst. C.E., Civil and Mining Engineer, Tredegar Mineral Estate Office, Cardiff

1857 BEDLINGTON, RICHARD (*Past President*), Mining Engineer, Gadlys House, Aberdare

1857 BROGDEN, JAMES (*Past President*), F.G.S., Sea Bank House, Porthcawl, Bridgend

1858 Banks, George Hatfield, Pontymeister Tin Works, Newport, Mon.

1858 Buckton, Joshua, Well House Foundry, Leeds

1859 Bell, J. Lothian, Ironmaster, Rounton Grange, Northallerton

1859 BROWN, THOMAS FORSTER (*Past President*), F.G.S., M. Inst. C.E., Civil and Mining Engineer, Cardiff

1862 BROWN, GEORGE (*Member of Council*), Colliery Manager, Navigation Colliery, Aberdare

1863 BIRBECK, GEORGE (*Member of Council*), Mineral Agent, Tondû Iron Works, Bridgend

1864 Baker, Alfred, Swansea

1865 Bodmer, J. J., 8 Bloomfield Street, London, E.C.

1865 Brain, William Blanche, Trafalgar Colliery, Coleford, Gloucestershire

1866 BATES, MATTHEW (*Member of Council*), Mining Engineer, Cyfarthfa Works, Merthyr Tydfil

Date of Election.

1867 Bewick, Thomas J., F.G.S., M. Inst. C.E., Civil and Mining Engineer, Hayden Bridge, Carlisle
1868 Bidder, B. P., Mining Engineer, Neath
1868 Begg, Hugh, Colliery Manager, Ton-y-efail, Pontypridd
1870 Batey, John, Newbury Colliery, Coleford, near Bath
1871 BARROW, JAMES (*Member of Council*), Mineral Agent, Maesteg, Bridgend
1871 Bell, Walter, Surveyor, Merthyr Vale Colliery, Merthyr Tydfil
1873 Bowen, Lewis L., Mining Engineer, St. John, Hanley
1876 Bell, James, Mining Engineer, Cardiff
1877 Burnie, Robt. J. D., Engineer and Managing Director, Swansea Waggon Works, Swansea
1877 Bolam, Hy. Geo., Agent Earl of Shrewsbury, Little Ingestre, Stafford
1878 Bain, Rd. Donald, H. M. Inspector of Mines, Newport, Mon.

C.

1857 Cox, John, Hawksbury Upton, Chipping Sodbury
1861 Cooke, Thomas E., Surveyor, Newport, Mon.
1870 Cooksey, John H., Mining Engineer, West Bromwich
1873 COLQUHOUN, JAMES (*Member of Council*), F.G.S., Tredegar Iron Works, Tredegar.
1873 Corner, John Oliver, Mechanical Engineer, Grove Villa, Redland, Bristol
1876 Cowper, Richard, Analytical Chemist, Tredegar Iron Works, Tredegar

D

1866 Davies, D., Viaduct Works, Crumlin, Newport, Mon.
1868 Daniel, Evan, Mining Engineer, Swansea
1868 Davis, David, Blaengwawr, Aberdare
1869 Davies, Thomas Getrych, Tyla Coch Colliery, Pontypridd
1870 Davies, William, Colliery Manager, Coedcae Colliery, Pontypridd
1871 Dunn, Fred. W., Colliery Manager, Llanharran, Llantrissaint
1872 Davies, Howell, Underviewer, Rhondda Merthyr Colliery, Treherbert, Pontypridd
1873 Deakin, T. H., Mining Engineer, Trafalgar Collieries, Coleford, Gloucestershire
1873 Davies, Saml., Ivy Lodge, Morriston, near Swansea
1874 Daniels, Iago, Colliery Manager, Brynstyfryd, Ty-pica Colliery, Pontypridd
1874 Davies, Edward, Bronierion, Llandinam
1874 Daglish, John, Mining Engineer, Tynemouth on-Tyne
1874 Deacon, Ernest, Mining Engineer, Post Office Chambers, Pontypool

E

Date of Election.

1857 EVANS, THOMAS (*Past President*), F.G.S., H.M. Inspector of Mines, Pen y Bryn, Derby
1867 Ellis, Thomas J., Bedwellty Cottage, Bargoed, near Cardiff
1868 Elliott, Sir G., M.P., Houghton Hall, Durham
1868 Evans, David, Colliery Manager, Bodringalt Colliery, Ystrad, Pontypridd
1869 EDMONDS, J. T. (*Member of Council*), Cwmavon House, Varteg, near Pontypool
1874 Evens, Thos., Civil and Mining Engineer, Windsor Place, Cardiff
1877 Evans, Thomas, Barrow Collieries, Bryncethin, Bridgend

G

1858 Greenwell, G. C., F.G.S., Mining Engineer, Tynemouth, Northumberland
1870 Green, J. T., Colliery Viewer, Abercarne Fach, Newport, Mon.
1870 Green, Joseph, Mineral Agent, Pontypool Works, Pontypool
1874 Grice, E. S., Patent Nut and Bolt Works, Cwmbran, Mon.
1876 Gooch, Chas. F., 2 Richmond Terrace, Park Place, Cardiff

H

1857 Hosgood, Thomas H., Pentrebach House, Merthyr Tydfil
1857 HUXHAM, HORT. (*Secretary*), F.G.S., M. Inst. C.E., Civil and Mining Engineer, Swansea
1863 Hale, Joseph, Powell's Llantwit Collieries, Pontypridd
1864 Hoskhold, H. D., F.R.G.S., F.G.S., M. Soc. A., Civil and Mining Engineer, London
1864 Huzzy, H. A., Mechanical Engineer, Stowgate Villa, Newport, Mon.
1868 Hunter, Charles L., Mechanical Engineer, 2 Belgrave Terrace Roath, Cardiff
1871 Harris, Henry, Mineral Agent, Blewitt House, Brynmawr, Mon.
1871 Heyworth, Lawrence, Waun Fawr House, Newport, Mon.
1873 Hewitt, Geo. Civil and Mining Engineer, Coal Pit Heath, Bristol
1874 HOOD, A. (*Member of Council*), Colliery Owner, Cardiff
1874 Hayhurst, Ed., Colliery Manager, Grasmere House, Aberdare
1875 Hay, John, Colliery Manager, Cwmllynfell Colliery, Ystalyfera
1875 Hamilton, Wm., Civil and Mining Engineer, Tredegar
1876 Harrison, Thos., Colliery Viewer, Gt. Western Collieries, Pontypridd

J

1857 James, Christopher, 8 Laurence Pountney Hill, London, E.C.
1857 James, Phineas, Mineral Agent, Abersychan, Mon.

Date of Election.

1857 Jones, Howell, Mineral Agent, Dowlais Iron Works
1857 Jordan, Robert, Mineral Agent, Ebbw Vale Works, Mon.
1857 Joseph, David, Rockleaze, Durdham Down, Bristol
1857 JOSEPH, THOMAS (*Vice-President*), Tydraw, Treherbert, Pontypridd
1865 Jones, Benjamin, Furnace Manager, Dowlais Iron Works
1870 Joseph, Morgan, Mining Engineer, Llanblethan Cottage, Cowbridge
1871 James, Chas. Henry, Mining Engineer, 8 Courtland Terrace, Merthyr Tydfil
1871 John, Mathew, Junr., Engineer, Merthyr Tydfil
1872 Jenkins, Thomas, Surveyor, Neath
1873 JORDAN, HENRY K. (*Member of Council*), F.G.S., 7 Cotham Parade, Bristol
1874 Jones, J. O., Mining Engineer, Swansea
1874 James, W. Phillip, Mining Engineer, Abersychan, near Pontypool
1875 James, William, Mechanical Engineer, Risca, Newport, Mon.
1875 Jones, Thos. J., Mining Engineer, Holford Villa, Cefn Coed, Merthyr Tydfil
1875 Jee, George John, Mining Engineer, Pontypool
1876 Jones, Henry, Mineral Agent, Ashvale House, Tredegar, Mon.
1877 Johnson, Moses George, Mining Engineer, Fishponds, Bristol

K

1861 Kirby, Conyers, Assoc. Inst. C.E., Newport, Mon.
1867 Kirkhouse, Herbert, Colliery Manager, Courtland Terrace, Merthyr Tydfil
1868 Kay, Joseph, Colliery Manager, Blaenavon Iron Works, near Pontypool

L

1857 Levick, Frederick, Sunbury House, Watford, Herts
1857 Llewellin, David, Assoc. Inst. C.E., F.G.S., Civil and Mining Engineer, Glanwern Offices, Pontypool
1858 LEWIS, WILLIAM THOMAS (*Past President*), F.G.S., M. Inst. C.E., Civil and Mining Engineer, Aberdare
1861 Lee, Mark, Mineral Surveyor, Tredegar Mineral Estate Office, Cardiff
1865 Langham, Goodrich, Coleford, Gloucestershire
1865 Lewis, Lewis Thos., Civil and Mining Engineer, Cadoxton Lodge, Neath
1867 Lewis, Henry W., Consulting Engineer, Treherbert, Pontypridd

Date of Election.

1868 Lewis, Evan, Engineer, Landaff Rise, Cardiff
1869 LAYBOURNE, RICHARD (*President*), M. Inst. C.E., Rhymney Iron Works, Mon.
1869 Lundie, George A., Engineer, Tweed Lodge, Cardiff
1871 Lewis, Walter, Mining Engineer, Swansea
1875 Llewellyn, Llewellyn, Mining Engineer, Aberaman, Aberdare
1875 Louie, Robt., Colliery Manager, New Tredegar Colliery, near Cardiff
1876 Lawrence, Arthur, Mining Engineer, 72 Crockherbtown, Cardiff
1877 Lewis, Henry, Mining Engineer, Energlyn Colliery, Caerphilly

M

1857 MARTIN, GEORGE (*Past President*), Mining Engineer, Dowlais
1857 MAYNARD, H. N. (*Member of Council*), Mechanical Engineer, Crumlin, Newport, Mon.
1857 MENELAUS, WILLIAM (*Past President*), Manager of Dowlais Iron Works, Dowlais
1857 Moody, John, Bedlwyn Colliery, Cwmaman, Aberdare
1858 MOXHAM, MARCUS (*Member of Council*), Swansea
1858 MURPHY, JAMES (*Vice President*), Assoc. Inst. C.E., Railway Works, Newport, Mon.
1863 Monks, W. B., The Grange, Hanham, Bristol
1865 Morgan, William, Cefn Iron Works, Bridgend
1867 McMURTRIE, JAMES (*Vice-President*), Mining Engineer, Radstock, Bath
1867 May, George, Chain Factory, Neath
1868 Morgan, David, Maesydderwen, Mountain Ash, Aberdare
1870 Morgan, Leyshon, Glanwern Office, Pontypool
1872 MARTIN, E. P. (*Member of Council*), Blaenavon Works, Pontypool
1873 Morgan, Thos., Mining Engineer, Dwrllas Colliery, Penclawdd, Swansea
1874 Morgan, Hy., Mining Engineer, Bute Villa, Llantrissaint
1874 Miller, Uriah, C.E., Penarth, Cardiff
1875 M'Culloch, William, Cwmpennar, Mountain Ash, Aberdare
1876 Moor, William, Mechanical Engineer, Engleholm, Sweden
1877 Morrison, Arthur D., Iron Master, Sudeley Works, Newnham

P

1857 Pearce, G. Cope, Mechanical Engineer, Cyfarthfa, Merthyr Tydfil
1864 Phillips, W. Douglas, 59 Upper Brook Street, Manchester
1870 Phillips, Daniel, Mining Engineer, Nantyglo Villa, Newport, Mon.

Date of Election.

1871 Price, Thomas Jones, B.A., Brynna Colliery, Bridgend
1872 Price, Thos. Morgan, Surveyor, Orchard Street, Neath
1874 Plummer, Edward, Colliery Manager, Glyncorrwg, Maesteg, Bridgend
1874 Piele, Wm., Mining Engineer, Oakfield Street, Roath, Cardiff

R

1858 Rosser, William, Assoc. Inst. C.E., Civil and Mining Engineer, Llanelly, Carmarthenshire
1867 Rees, Daniel, Glandare, Aberdare
1868 Reynolds, Morgan, Mining Engineer, Dynevor Colliery, Neath
1873 Richards, John, Engineer, Newport, Mon.
1874 Rees, David, Tynybedw Colliery, Pentre, Pontypridd
1874 Roberts, John, Mining Engineer, 17 Henrietta Street, Swansea
1874 Randall, J. M., Mining Engineer, Bridgend
1876 Richards, Edward Thos., Mining Engineer, Thomas Town, Merthyr Tydfil

S

1856 SMITH, JOHN (*Member of Council*), Mineral Agent, Abernant Iron Works, Aberdare
1860 STEEL, T. DYNE (*Past President*), M. Inst. C.E., Civil and Mining Engineer, Bank Chambers, Newport, Mon.
1861 Slater, Isaac, Manager Gloucester Wagon Company, Gloucester
1863 Stenson, Wm. T., Coalville, Leicester
1866 STEVENS, ARTHUR J. (*Member of Council*), Uskside Iron Works, Newport, Mon.
1868 Simpson, John, Heyworth Colliery, Gateshead-on-Tyne
1869 Snape, John, Engineer, Powell's Duffryn Colliery, Aberdare
1870 Stewart, Wm. Prosser, Colliery Manager, Mamhole Collieries, Blackwood, Newport, Mon.
1870 Stephens, Fred. Cook, Bilboa
1874 Smith, Wm., Colliery Manager, Oakwood Colliery, Maesteg, Bridgend
1874 Southern, Robt., Mining Engineer, Cardiff
1877 Sheppard, Charles, Mechanical Engineer, Bridgend
1877 Sheppard, Oliver, Mechanical Engineer, Bridgend

T

1857 THOMAS, DAVID (*Vice-President*), Consulting and Mining Engineer, Penceira, Neath
1857 TRURAN, MATTHEW (*Vice-President*), Mining Engineer, Dowlais Iron Works, Dowlais

Date of Election.

1858 TRUMP, HENRY V. (*Member of Council*), Mill Manager, Rhymney Iron Works, Mon.
1865 Thomas, William, F.G.S., Mining Engineer, Glyn Castle, Resolven
1867 Thomas, William, Junr., Mineral Surveyor, Gadlys Iron Works, Aberdare
1874 Thomas, Thos., Engineer, 34 West Bute Street, Cardiff
1874 Thomas, J. Shenton, Colliery Manager, Primrose Collieries, Swansea
1874 Thomas, John Gwillim, Colliery Manager, Ifor Cottage, Pembrey, Caermarthenshire
1876 Thomas, John, Colliery Manager, Resolven

W

1857 WILLIAMS, EDWARD (*Member of Council*), M. Inst. C.E., Middlesborough, Yorkshire
1857 Worthington, George, Colliery Proprietor, Llancaiach, Cardiff
1864 WADDLE, J. R. (*Member of Council*), Mechanical Engineer, Llanelly, Caermarthenshire
1864 WILKINSON, GEORGE (*Vice-President*), Colliery Manager, Duffryn, Aberdare
1865 Weeks, J. George, Bedlington Colliery, Morpeth, Northumberland
1868 Warren, John, Engineer, Victoria Chambers, Newport, Mon.
1874 Widowfield, F., Powell's Duffryn, Cardiff
1875 Williams, Lewis Ambrose, Mining Engineer, Coity Road, Bridgend
1876 Williams, Wm. Thos., Mining Engineer, Aberdulais, Neath
1876 Williams, Eustace Robt., Surveyor, South Wales Colliery, Cwmtylery
1876 Walters, William, Colliery Manager, Briton Ferry
1876 Williams, Morgan Bransby, M. Inst. C.E., Swansea
1878 Williams, E. C. Elworthy, Mining Engineer, 37 Britannia Chambers, Bute Docks, Cardiff

Y

1876 Young, Herbert Harry, Colliery Manager, Corrwg Fechan, Glyncorrwg

ASSOCIATES

1858 Evans, Henry Jones, Cardiff
1865 Austin, W. L., Cambria Works, Sheffield
1869 Davis, Lewis, Cardiff

GRADUATES

Date of Election.	
1869	James, James N., Sirhomy Works, near Tredegar
1870	Bedlington, Wm. David, Aberdare Rhondda Colliery, Hirwain
1871	Joseph, David, Junr., Tydraw, Treherbert, Pontypridd
1872	Steel, William Brook, Oxford Buildings, Swansea
1872	Thomas, John Howard, Ysgyborwen, Aberdare
1875	Dalziel, W. G., Bute Mineral Estate Office, Aberdare
1875	Evans, D. L., Goldtops, Newport
1876	Findlay, Jas., Surveyor, Tredegar
1876	Gray, Fred. A., Underhill House, Taibach
1876	Bedlington, Peter Roe, Aberdare
1876	Jones, Thomas, South Wales Colliery, Cwmtylery
1876	Vachell, Theodore, Cardiff
1876	Sadler, Frank L., Maesteg
1876	Stockwood, Saml. Hy., Maesteg
1877	Jones, Edmund James, Myrtle Grove, Blackwood, Newport
1877	Lewis, Edmund Roger, Brecon Road, Hirwain
1877	Thomas, Daniel, Gelli Colliery, Ystrad Rhondda
1878	Thomas, Azariah, Ynishir Colliery, Pontypridd

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PROCEEDINGS.

8th June 1876.

The Ordinary General Meeting of the Institute was held at the Town Hall, Cardiff, on Thursday, the 8th June 1876.

Mr. JAMES BROGDEN, F.G.S., President, in the chair.

The Minutes of the last General Meeting were read and confirmed.

ELECTION OF NEW MEMBERS.

The President announced that the Ballot Lists had been opened, and declared the following gentlemen to have been duly elected as Members of the Institute, viz.:—

Members.

Mr. Edward Thos. Richards, Mining Engineer, Thomas Town Merthyr Tydfil.

„ William Thos. Williams, Mining Engineer, Aberdulais, Neath.

„ Herbert Harry Young, Colliery Manager, Corrwg Fechan Colliery, Glyncorrwg.

„ William Lamb Armstrong, Mining Engineer, Dunraven Collieries, Treherbert.

Graduate.

Mr. Frederick A. Gray, Mining Engineer, Taibach.

ADMISSION OF NEW MEMBERS.

The following gentlemen, elected at previous meetings, were then formally admitted to the Institute by the PRESIDENT, and signed the Roll Book, viz. :—

Mr. Charles Fulthorpe Gooch, Cardiff.
„ Robert Lonie, New Tredegar.
„ John Hay, Ystalyfera.

INAUGURAL ADDRESS.

The PRESIDENT then delivered his Inaugural Address, as follows, viz. :—

I have to thank you, gentlemen, for the honour you have conferred upon me in electing me to the Presidency of your Institution, and for the confidence you have shown in placing me in that elevated position in connection with so practical an Association as the South Wales Institute of Engineers.

The field of investigation available to its members is very large, since it is not confined, as in some kindred institutions, to the study of one branch of engineering, nor does it concern itself exclusively with the manufacture of iron and steel, but extends its researches into a far wider domain, and welcomes among its members all whose technical studies are pursued in connection with civil and mechanical engineering in all their branches: chemistry, copper mining and manufactures, coal and iron mining, and the smelting of these, and their varied uses, the application of electricity, the use of mineralogy and geology.

In fact, it is somewhat hard to define any limits within which its investigations can be confined, or to close up any avenue of usefulness in connection with the trade and industry of this extensive district. Our members consist of individuals of varied studies, corresponding somewhat with the subjects.

Technical study and technical education are now much more the order of the day, for it has been found that the true searcher for Truth has to follow the slightest traces which indicate a solution of his difficulty, as the miner has to follow the leads or veins to attain the sought-for treasure.

We find that interests are grouped for special study, as in the case of the Iron and Steel Institute, an offshoot of the parent Civil Engineers, so the Mechanical Engineers, Telegraphic Engineers, Chemical Society, &c. &c.

The district of South Wales has, in its mineral aspect, been partly described in the valuable papers communicated to our Institute, with the exception, I may say, of the Anthracite districts. We have, however, ascertained that South Wales in itself has a great development to look forward to, consequent on the mineral resources she possesses, coupled with the well ascertained and favourable comparative value of her coal. We may be at the moment suffering from the bad trade which has paralysed our iron manufacture, and thrown the coal, otherwise consumed by that industry, upon an already overstocked market, but it will not be deemed rash, I hope, to express an opinion that, notwithstanding the production in other parts of England, or the discovery and working of coal in other countries, our naturally condensed coal will have a greater consumption than ever, and will be a favourite fuel where the cost will enable it to compete with other districts.

It has been frequently remarked, that the coal trade is dependent on the iron trade. I venture to think that in respect to the South Wales coal trade, the reverse is the case. It is the fuel that has enabled the ironmasters to carry on business with success in South Wales, for, except in some few cases, the ironstone has to be imported to the works, and costs per unit of iron more than that supplied from the ironstone workings in Scotland, Lancashire, Middlesboro, Yorkshire, and Staffordshire.

As a local Institution we are pre-eminently and deeply concerned in everything which relates to the prosperity of South Wales, and the importance of our coal industry places it naturally first in order for consideration. We have had our coals analysed and compared with those of other districts, and the chemists show us that we have in our steam coal a larger amount of fixed carbon, with less impurity, than exists in those of

other parts of England, and we have the tests of practical use and comparative tables issued by our Government from the various dockyards.

Some other tests have been made in the following manner :

TEST TRIALS OF COAL.

	1	2	3	4	5	6	7
Coal in lbs. . . .	1,680	1,680	1,680	1,680	1,680	1,680	1,680
Water in lbs. evaporated	15,120	18,360	16,200	18,900	17,280	19,440	19,440
lbs. of Water evaporated per lb. of Coal . .	9	10·92	9·6	11·2	11·27	11·5	11·57
Ash and Clinker in lbs.	233	33	86	52	64	50	60
Percentage of Clinker	13·86	1·98	5·1	3·09	3·8	2·9	3·57
Pyrometer Heat . .	600°	650°	600°	650°	700°	725°	750°
Number of Hours .	3¼	4	3·50	3¼	4	4	3¼

The theoretical value is seldom over 15 lbs. of water evaporated by 1 lb. of coal, so that the above tests for the conversion are little more than two-thirds, or 66 per cent. of the theoretical quantity to be got out of the coal.

Possibly, however, the best evidence that can be given is the fact of its extensive use by our Mercantile Marine from motives of economy, which has shown that there is a superior value to be attached to the South Wales coal. The old saying, however, 'that you may buy gold too dear' is equally applicable to coal, and the prices demanded for South Wales coal, and in fact, of late, the difficulty of obtaining it at all, on account of the disturbed state of the labour-market, have driven the consumers to adapt their apparatus to the use of other fuel. Many ocean-going companies, having made this change, find it costly to reconstruct; and only a few days ago I was told by one of the largest coalowners in South Wales that, whereas the 'time was when we got 2*s*. per ton above North Country coal, now we are absolutely 2*s*. below,' while, in his opinion, the normal value of South Wales coal to the shipowners would be nearly 2*s*. more than other coal, as tested by actual use.

The demands made for the coal by coalowners and merchants, the effect of recent legislation causing increased cost and limitation of the hours of work, and the incessant requirements made by labour, with its lamentable short-sightedness, have forced a premature development of other resources for the

world's supply; for it must not be assumed that Great Britain holds her present position amongst nations solely because of the mineral wealth she alone possesses.

She has serious rivals in this respect with mineral resources of immense dimensions, whom she will have eventually to meet in the markets of the world; but, by a fortunate combination, her minerals are in juxtaposition, and can thus be made easily available. She has had a market to begin with at home, a growing one amongst her colonies, and in foreign countries, thanks to the adoption of a sound financial policy, she has had the largest merchant navy, has been the first in the field in civil and naval engineering, and has thus been enabled to find new applications for the produce she possesses, and fresh developments for the industry of her sons.

We learn from the official returns that the *coal and iron produced* during 1874 in the United Kingdom

From 4,112 Collieries was	125,043,257 tons
Total value of Coal produced during 1874 . .	£45,849,194
Iron Ore raised during 1874 in the United Kingdom	14,844,936 tons
Foreign Ore imported (including Burnt Ore) .	1,009,141 „
Total quantity smelted in 649 Blast Furnaces .	15,854,077 tons
Total value of Iron Ore production during 1874 .	£7,318,169
Pig Iron produced during 1874	5,991,408 tons
Coal used in its manufacture	15,292,201 „
Total Value of Pig Iron produced during 1874 .	£16,476,372

Summary of Coal and Iron Ore produce of the United Kingdom, 1874—

Coal .	125,043,257 tons	*Value*	£45,849,194
Iron Ore	14,844,936 „	„	7,318,169
Total quantity	139,888,193 „	Total value	£53,167,363

showing a decrease, as compared with 1873, in the value of—

Coal of	£1,782,086
Pig Iron of	1,581,367
	£3,363,453

Our Foreign Trade in *Coals* has *increased in quantity* each year during the past three years, while the *amount in value* has considerably *declined*; thus, in the

	Tons	Value
Year ending Dec. 31, 1873, the quantity exported was	12,617,566	£13,188,511
„ „ 1874 „ „	13,927,205	11,984,621
„ „ 1875 „ „	14,475,036	9,645,962
Exports of Coal, Coke, Cinders, and Fuel during the *Four Months* ending 30*th April* 1874 . .	3,975,769	3,894,053
„ „ 1875 . .	3,536,464	2,544,774
„ „ 1876 . .	4,470,223	2,561,754
Coal &c. shipped for the use of Steamers engaged in Foreign Trade during the four months ending 30*th April* 1874	968,374	
„ 1875	975,373	
„ 1876	1,064,284	

A similar decline in value of nearly all exported commodities has taken place *during the present year*; but coal and coke are most startling of all, having been sent abroad (referring to the returns of the Board of Trade for January 1876) in greater quantity by 45 *per cent.* than in January 1875, yet the value is only greater by about 15½ *per cent.*

France, Germany, Sweden and Norway were our *largest purchasers of coal* in the year 1875, followed by Italy, Russia, Spain, Denmark, British India, Egypt, Holland, Brazil, and Malta; their respective purchases being—

	Tons	Value
France . . .	2,705,494	£1,617,730
Germany . . .	2,154,367	1,263,639
Sweden and Norway .	1,139,273	750,829
Italy . . .	954,694	645,899
Russia . . .	884,861	617,660
Spain and Canaries .	690,762	530,796
Denmark . .	760,719	458,594
British India . .	608,259	454,278
Egypt . . .	532,376	402,124
Holland . . .	455,201	303,891
Brazil . . .	365,172	294,288
Malta . . .	228,081	170,778
Various small exports to other countries .	2,753,859	1,957,435
Total tons .	14,475,036	Total Value £9,645,962

The iron and steel exports during the years 1873–4–5 show a decline in *both value and quantity*, the falling off in value last year being especially noticeable, thus:

	1873	1874	1875
Total quantity of Iron and Steel exported . .	2,957,813 tons	2,487,522 tons	2,465,640 tons
Value of ditto . .	£37,731,239	£31,190,256	£25,781,421

The classified returns of the Board of Trade, under the respective heads of *Pig iron*, *Bar and Rod iron*, *Railroad iron*, *Cast, Wrought, and Manufactured iron*, exhibit a similar declension of quantity and value for the exports of the last three years, as follows:

	1873	1874	1875
Pig Iron, *quantity exported*	1,142,065 tons	776,116 tons	954,475 tons
„ *Value* . .	£7,118,037	£3,673,734	£3,474,621
Bar, Angle, Bolt, and Rod Iron . . .	286,845 tons	258,953 tons	276,686 tons
„ „ *Value*	£3,755,980	£3,054,547	£2,729,833
Railroad Iron, *quantity* .	785,014 tons	782,665 tons	546,547 tons
„ *Value*	£10,418,852	£9,638,236	£5,459,898
Cast, Wrought, and Manufactured . . .	282,000 tons	257,069 tons	240,041 tons
„ „ *Value*	£5,478,759	£5,122,588	£4,342,615

Exports of the above for the four months ending April 30, 1874, 1875, 1876:

	1874	1875	1876
Pig Iron, *quantity exported*	208,324 tons	265,220 tons	239,807 tons
„ *Value* . .	£1,145,590	£1,069,228	£801,998
Bar, Angle, Bolt, and Rod Iron	74,426 tons	82,048 tons	69,471 tons
„ „ *Value*	£969,837	£857,070	£640,992
Railroad Iron, *quantity* .	237,506 tons	151,921 tons	94,424 tons
„ *Value* .	£3,137,462	£1,580,424	£858,768
Cast, Wrought, and Manufactured . . .	76,180 tons	70,729 tons	72,357 tons
„ „ *Value*	£1,560,895	£1,376,155	£1,245,181

The falling off in the demand for our commodities by the *United States* is shown by the following comparisons:

	1873	1874	1875
Pig Iron, quantity exported . .	102,624	43,568	49,868
Bar, Angle, Bolt, and Rod . .	22,676	4,729	3,264
Railroad Iron of all sorts . .	186,300	94,491	17,789
Cast, Wrought, and Manufactured .	22,571	20,058	7,818

Steam Engines, 1873 .	£2,927,617
„ 1874 .	3,255,685
„ 1875 .	2,620,491

It has been stated that, with the best appliances, in the shape of boilers and engines, yet discovered for converting one ton of coal into what we term horse-power, the most useful effect is only ordinarily 10 per cent. to 20 per cent., and the utmost that has ever been reached is from 25 per cent. to 30 per cent. of what it is calculated as theoretically the amount. How are these statements verified? you may ask. Well, in an easy form. I may show you on the face of the case that because various classes and seams of coal require different fire-grates, different speeds of burning, different means of admitting the air to form combination of gases properly, that failure of these conditions alone would allow a loss of calorific value to disappear up the chimney. The usual way in which the coals have been tested for Government purposes has been therefore the most crude. You are all acquainted with the mode of doing this: the same boiler, the same grate space, the same means of admitting air with every class of coal.

Now in the tests I have had occasion to have made, it has been found that few coals burn in the same manner, and that to accomplish a true test of their value you must take into consideration, with the pyrometer, the heat of the escaping gases, and to ascertain, by analysing, that the whole of the combustible products have been converted. Many of the tests were made as to evaporative power in a stationary two-flue boiler of the Lancashire type, in which the pressure of the steam was about 60 lbs. per square inch.

In estimating the possible increase of effective work to be obtained from the combustion of coal, I must point out that there is the very important item of the application of the mechanical

means to convert it into useful effect. With this view it will be well to draw the attention of our engineers to these facts, that by raising the temperature of the steam under high pressure, the rates of power, to the consumption of units of heat, presents apparently one of the most profitable modes of future economy. We have gone on increasing boiler pressure from 10 lbs. to 280 lbs. on the square inch, and as the tables (see p. 19) show the consumption of units of heat as compared with the power created, it is clearly economical if proper means can be devised.

In converting each pound of water into steam 537 units of heat become latent, and not more or less whether we use steam at 10 lbs. or 280 lbs. pressure.

Improvements at present seem to indicate the use of such boilers as the 'Field,' or 'Howard' type, or possibly with the water in the tubes and the combustion chambers surrounding. Again, it has been found difficult to work the steam at this high temperature, as it burns the packing, and it is hard to lubricate the piston and cylinder. I am informed that a great step towards overcoming this difficulty has been made in the application of phosphor bronze, in the parts exposed to the heat and friction. A small engine of this material, weighing only 7 lbs., has been made to develop a power of three horses, at 1,000 lbs. pressure, to be put in a torpedo for its propulsion; of course this is to be worked by air, and has no reference to the above; I mention it incidentally.

It is evident that we must maintain our position by being able to produce a certain amount of duty in the shape of effective horse-power on the most economical terms. As engineers we may study the best methods of constructing the most suitable machinery; and as miners we must see how far we can reduce the cost of our production, and to utilise all that is got.

Let us begin, then, in a practical way to divide the items of our cost-sheet, thus:

1. Cutting coal at contract prices.
2. Laying roads in stalls and general repairs.

3. Underground daymen.
4. Ordinary deadwork.
5. Engineers, firemen, fluemen, and deputies.
6. Artisans and labourers.
7. Surface daymen.

= Total wages.

8. Horses.
9. Coal consumed by engines, &c.
10. Stores.
11. Pitwood.
12. General charges.
13. Royalties.
14. Interest and sinking fund.

We shall find that upon the first item, 'Cutting coal at contract prices,' we may by perseverance be yet enabled to relieve the working collier from some of the heavier portion of his employment, and by mechanical arrangements requiring skilled supervision may elevate his labour, and thus cultivate his intelligence. Attempts have been made with varying success in trials which have been made within my own observation with Firth and Donnisthorp's machine. The cost was brought down to the lowest cutting rate for the coal. The roof, however, was not sufficiently good, and therefore the trial did not afford evidence of the possibility of permanently working the machine. If success can be attained, we should see the following remarkable results.

Relief would be secured to the collier from much manual labour, there would be an increased get from the same working faces, an easy mode of arriving at double turn; and so, by getting double quantity out of the same area repairs and maintenance would be proportionately less; in fact, all items in the cost-sheet excepting Royalties would be considerably reduced. That an easier method of working hard coals will be discovered and applied I have no doubt, and I commend this important question to the study of our Members, whether Mechanical or Mining Engineers.

The adoption of the system of the double shift, even under the labour system, in the harder seams, where the cutting is the limit of production, would affect very advantageously the same item of cost, without in any way inflicting loss or injury upon the workman; while it would be a means of economy to the colliery, and would reduce the number of hours during which the cutter would be required to work below in the mine. Indeed, to those practical men who are acquainted with the system, the prejudice of our Welshmen against its adoption is beyond comprehension. Another mode of saving under this head, in those collieries where the cutters set timber, open stalls, repair top or bottom, or relay roads, and do everything as well as cut coal, will be to divide each kind of work, so as to give to a timberman specially the setting of timber, to another special man the repairing of the roadway and laying of road, and thus to apply the system of division of labour throughout the colliery.

I speak generally, of course, as these remarks will apply more specially to the collieries where the long wall system is in use. Wherever the district or the face of workings is rapidly pushed forward, experience shows that not only does more coal come out, but repairs are less and the items of cost mentioned above are all proportionately decreased.

With regard to item three, 'underground daymen,' much may be done to reduce this charge by the application of hauling by machinery, by due care in preserving good headings, properly supported by sufficient pillars, and by either permanently arching in the headings and the airways, or by proper timbering with lasting timber, or even with creosoted props. I may add also that permanent roads should be carefully constructed, having regard to gradients and curves, with proper rails, with sleepers that will last, and with as much consideration as if the road were to be used by locomotive engines. I have observed a tendency to treat main roads as if they were but temporary roads, and that the timbers have had only a short life of some three or four years in the intakes, and half that time in the

returns. So also the sleepers have been cut from fresh prop-wood, laid, and in a few months have become either worn out in the spike places, or in a short time longer have rotted in the damp places in the road. I think I may venture to recommend for the consideration of the Members of this Institution the use of properly prepared timber for roads. It is a saying amongst railway men that they have never seen a rotten creosoted sleeper.

In New Zealand the Government began by laying down their 3ft. 6in. gauge railways upon sleepers cut from native woods called Purri, Totara Kauri. Some only of these would withstand the weather. They constructed viaducts of Totara, a beautiful timber, apparently cut from giants of the forest; but as the whole of these were unprepared, the sleepers are mostly useless, and the viaducts are going already, though I felt so convinced that even the more transient woods, such as Matai (*Podo Carpus spicata*) and Birch (*Fagus fusca*), might be preserved by the creosoting process, that I strongly urged the Government to try it, and sent particulars through our engineers. I may do the same to you, though the results may not be so evident. If the process is found to answer its purpose, you will save replacement, labour, and material.

The fourth item of cost, 'ordinary deadwork,' will be greatly affected by the mode of laying out the work, and is to some extent a matter of separate experience in every different colliery, depending upon which class of work is adopted, the pillar and stall, or the long wall; upon the distance of headings and cross-headings, the height for roads to be maintained, which will be much ruled by the height of horses, and the size of trams, with the load which they are to carry.

I am still under the impression that the very large tram used in the Aberdare district is not so economical as the smaller one. I need scarcely say more on the question at the present time, having previously expressed my opinion in a paper already submitted to the Institute; but I think, in combination with the

use of hauling by engine power, instead of by horse power, a considerable difference may be made in the item of ordinary deadwork, by being able to work in less height by means of the ropes than in the case of horses, and more especially would this be the case with a lower tram. I cannot think that we have in this district given the attention it deserves to the proportion of the deadweight of the tram to the amount of load carried. In these days, when steel seems to be taking the place of iron, where light construction combined with strength is required, I think it will not be long before some of our practical men will devise a tram which will be easily taken to pieces and repaired, and yet be durable and light, so as to convey a much greater proportion of paying load to its own deadweight than has yet been accomplished. I think some want of success, and the existence of considerable prejudice, may have discouraged the attempts of some of our Members in that direction. It requires a little effort of mind to discriminate between prejudice and proof. An amusing discussion took place in the early history of the Duffryn Llynvi Railway, which was one of the very earliest of the railways of England and Wales, and is now merged into the Llynvi and Ogmore system, as to the advisability of their using cast-iron or wrought-iron rails. It was decided in favour of the cast-iron; because, if wrought-iron were used, it was believed the blacksmiths of the country would steal them to convert them into horse-shoes. The price of steel offers now no similar temptation, but only presents for the while a difficulty of manipulation to these same vulcanite brethren.

The durability of the underground rolling stock, combined with lightness, will be found to influence the cost of labour throughout to a greater extent than anyone can well conceive. At present it takes two or even more men to move the empty trams of the Aberdare district; and applying this idea to labour underground, and to all surface arrangements, you will find there will be a difference of about one-half on these charges influencing the items numbered from one to eight.

I trust that the proposed visit of our Members to the Wigan district will make them weigh well this matter. The two classes of application, as worked out in Wales, have come under my own personal direction, and I should be sorry to refer to this matter so strongly, without having had the opportunity of learning its importance from personal experience.

I may pass over the item of engineers, firemen, fluemen, and deputies, with the observation that the number of engines, and the times at which they have to work, will differ in every colliery, and their special cost may be considerably increased where the new system of engine haulage power is employed to replace horses, though great economy will be the general result of the change.

In the same way firemen and deputies will be required as the districts may be formed and worked, but it appears that even in this day, in some collieries, sufficient attention is not given to the forming of separate districts, and the working out of them in reference to separate ventilation, and the ultimate closing of them when worked, so as to avoid the danger of large accumulated bodies of gas in the goafs, and also that in case of accident the works in one district only will be influenced. With regard to fluemen, I should hope that machine ventilation will replace this necessity, as it is proved to be more economical than furnace ventilation in pits of moderate depth, and much more safe in its application.

No. 6. 'The cost of artisan labour' is under the control of the colliery manager, it is usually much more than necessary, and may be economised by the use of duplicates in every department of colliery plant where such use is possible.

No. 8. 'The horse account' may be considerably economised by care and attention. I would urge all colliery managers, first, to try to dispense with as many horses as possible by using engine power, as you can work to the deep with advantage, as well as to the rise of the measures where the coal is unwatered. I know of collieries where engine-power is employed working 500 tons per

day with four horses, and I know of others on the old system of horse-power alone, which require seventeen horses on the surface and have taken eighty-four horses underground to work from 600 to 700 tons, and I believe the proportion in this latter case to be an example of only one out of many similar instances in our South Wales district.

The following, which appeared some time since in a Bristol newspaper, contains some valuable hints on the management of horses.

To keep a horse, say sixteen hands, in perfect health and fit for work in a loose box:

6·0 A.M. Clean horse, and put stable to rights.

6·30 A.M. 2 gallons of water, with chill off in cold weather.

7·0 A.M. Feed: 2 lbs. best black oats (crushed), 1 lb. best hard beans (crushed), 2 lbs. best hay chaff, properly mixed, and given dry.

8·30 A.M. 5 lbs. best hay from rick.

1·0 P.M. (Or one hour after return from drive.) Feed: 2 lbs. best black oats (crushed), 1 lb. best hard beans (crushed), 2 lbs. best hay chaff.

6·30 P.M. Feed: 2 lbs. best black oats (crushed), 2 lbs. best hard beans (crushed), 2 lbs. best hay chaff.

7·30 P.M. 3 gallons of water, with chill off in cold weather.

8·0 P.M. 7 lbs. best hay from rick.

Avoid carrots, never use bran mashes except when horse is unwell.

Give good bed at first, and add one sheaf of straw every night.

Horse should be cleaned down immediately after being used, and not fed for one hour.

Total per day: 6 lbs. oats, 6*d.*; 3 lbs. beans, $4\frac{1}{2}d.$; 18 lbs. of hay, 1*s.*; 1 sheaf of straw, $2\frac{1}{2}d.$: 2*s.* 1*d.* per day, or 14*s.* 7*d.* per week.

I also give you the following table of cost of horses in several pits and levels simply for the sake of comparison with your own

work, and not with a view of showing anything like so satisfactory a state of things as can be wished.

HORSE ACCOUNT FOUR WEEKS (22 WORKING DAYS), IN 1876.

Horses	Oats lbs.	Beans lbs.	Maize lbs.	Bran lbs.	lbs. per day each Horse	Hay lbs.	Straw lbs.	Saddlery	Medicine	Total cost per day per Horse
						T. C. 4 3½	TON. 1·0			
39	11201	589	6888	656		9352	2240	£6 4 7	£1 0 0	
	10·25	·54	6·30	·60	17·69	8·56	2·05			
	3/9	6/6	4/6	6/6		7/	2/			
	12·13*d.*	·70*d.*	5·67*d.*	·41*d.*		6·42*d.*	·44*d.*	1·36*d.*	·21*d.*	2/3·34
						CWT. QRS. 14 3				
7	2208	37	1344	155		1652	...	£0 14 9	£0 10 0	
	11·26	·18	6·85	·79	19·08	8·42	...			
	3/9	6/6	4/6	6/6		7/	...			
	13·33*d.*	·23*d.*	·55*d.*	·55*d.*		6·31*d.*	...	·90*d.*	·61*d.*	2/4·09
						T. C. QRS. 2 2 0	TONS. 2			
16	4475	205	2652	347		4704	4480	£2 2 2	£0 10 0	
	9·98	·45	5·91	·77	17·11	10·50	10·00			
	3/9	6/6	4/6	6/6		7/	2/			
	11·81*d.*	·58*d.*	5·31*d.*	·53*d.*		7·87*d.*	2·14*d.*	1·12*d.*	·26*d.*	2/5·62
2	439	50	278	45		896	...	£0 2 0	... ...	
	7·84	·89	4·96	·80	14·49	16·00	...			
	3/9	6/6	4/6	6/6		7/	...			
	9·28*d.*	1·15*d.*	4·46*d.*	·55*d.*		12·00*d.*	...	·42*d.*	... ...	2/3·86
1	191	...	98	23		336	...	£0 1 6	... ...	
	6·82	...	3·50	·82	11·14	12·00	...			
	3/9	...	4/6	6/6		7/	...			
	8·07*d.*	...	3·15*d.*	·57*d.*		9·00*d.*	...	·64*d.*	... ...	1/9·43
2	418	197	...	...		364	112	... ...	... ...	
	7·46	3·51	...	...	10·97	6·50	2·00			
	3/9	6/6	...	...		7/	2/			
	8·83*d.*	4·56*d.*	...	...		4·87*d.*	·42	... ...	... ...	1/6·68

I could give many more examples, but I think the above will suffice to show the great difference that may exist in a large establishment, consequent upon the presence or absence of due care in this department. It is said that the omnibus proprietors have worked this matter up most carefully, and they have been enabled to reduce cost by using a larger quantity of maize than has hitherto been customary. I hope we may have a well digested paper on this subject read before our Institute, as it is quite within the objects of our Society, and the subject is one of

considerable importance as affecting the cost of colliery management.

In reference to the coals consumed by the engines at the generality of our collieries, I think it must be admitted that proximity to a coal pit has rather tended to undue waste. In many cases the most economical boiler arrangements have not been adopted, but I believe the endeavour has recently been urgently made by many coal-owners to consume the small and inferior coals at the colliery. I must ask the members to consider this item later on, but I may say that as the cost in some large collieries varies from 3*d*. to 5*d*. per ton, and has been reduced by good appliances to some 1½*d*. per ton, where there is as nearly as possible the same proportionate quantities of water to pump and coals to lift—in fact made under similar conditions by the use of small coal, and economical arrangements in the boilers, including winding and pumping machinery—there may be some good reason to refer to these arrangements from time to time.

With regard to other items in the list of cost, viz. stores, pit-wood, general charges, royalties, interest and sinking fund—I had intended to debate these more fully, but time and space will not permit; they will vary at every colliery, and, in fact, with every different management and under every different lease; but I have rather wished to mention the practical department of our working, with a view of pointing out opportunities for saving of cost, and therefore securing an increased amount of prosperity to our coal interests.

I may say on the subject of the small steam coal left underground, that it represents an enormous loss of capital, and deserves the most earnest attention of our members, and that I believe a great deal of it can be profitably brought to the surface and utilised; there can be no doubt that by proper arrangements it can be made to do all the duty at a colliery, and that it can be purified by washing at no great cost, without involving any pollution of our rivers. We also know that it can be converted into a commodity of value, which can be put by and held in

stock, in the shape of what is called 'patent fuel,' without depreciation; and if it can be made at a reasonable cost, which I believe to be quite possible, it ought to be as legitimate an article for capitalists to invest money upon, as warrants for pig iron in Scotland and other districts.

A use has been found for the bituminous small coal in the manufacture of coke, and many efforts have been made to utilise the waste gases from what is justly termed the destructive distillation of the coal: the waste heat has been variously applied, and with care and arrangements it can be made to raise steam, &c. As yet, however, no satisfactory or profitable process has been found on a large and profitable scale to condense the gases which are volatilised in the manufacture of coke: if the valuable gases which are driven away could be made available, it is proved that an enormous consumption of fuel would be saved in the manufacture of iron, and generally wherever coke is used. The necessity for coking has been forced upon us from at least two causes, the one to drive away the sulphur which exists in white ash coals as sulphate of lime, and in the red ash coal as iron pyrites, which latter may also, to a great extent, be removed by washing; and hence the washed coal from the red ash series will make as good a coke for iron-making purposes as that from the celebrated white ash coals; and secondly because the small coal, if put on the blast furnace or into the cupola, prevents the atmospheric air from penetrating the mass, and which, so soon as it comes into the zone of heat, unites into a solid body.

With regard to the sulphur, which is held in a manner which may be termed mechanically, the washing of the small coal reduces this quantity very materially indeed, as is found by examination of the residuum small dust taken from the washing machine itself; couple this with the reduction of shale—say in the case of dirty small coal—it would imply a total loss of some 12 per cent., and at the cost of (say) some $1\frac{1}{2}d.$ to $2d.$ per ton for washing, to which must be added the loss by waste; you have

then an article which will at once make so palpable a difference as to be indicated in its effects in the blast furnace by the following figures:—The quality of iron is improved at least from one to two numbers, which is usually represented by from 2*s.* 6*d.* to 5*s.* per ton in value, and the consumption of coke per ton for white pig iron is reduced by about 2 cwt. per ton; the production of iron from one furnace has been increased from a make of about 225 tons per week to 300, thereby effecting a very considerable saving in wages, general charges, and all other items of that description, which in the total represents a value of something over £4,000 per annum on one furnace when it has been using dirty coke.

According to the tests made by Professor Playfair and Sir H. de la Bèche, we find as a mean of 17 different kinds of English, Welsh, and Scotch coals, that we have as combustible matter—

Elements	Coal	Coke	Wood			Peat	
			Perfectly dry	Ordinary state	Charcoal	Dry	Ordinary state
Carbon . . .	·812	·850	·510	·408	·930	·580	·464
Hydrogen . .	·048	...	·053	·042	...	·060	·048
Oxygen. . .	·054	...	·417	·334	...	·310	·248
Nitrogen and Sulphur. .	·031	...	...	·200	...	...	·200
Water . . .	...	...	...	...	...	...	...
Ashes . . .	·055	·150	·020	·016	·070	·050	·040
	1·000	1·000	1·000	1·000	1·000	1·000	1·000

The following table shows the calorific power of combustibles:

H Burning to water	Carbon to CO_2	Carbon CO
34462	8080	2403

From the above we have for *coal*

Carbon ·812 × 8080 = ... 6560·960

Hydrogen ·048 less ·006 to combine with the ·054 oxygen in the coal = ·042 × 34462 = 1447·404

Divide by latent heat of steam . . 537) 8008·364

= Theoretical value in lbs. of water, evaporated by 1 lb. of coal = . . . 14·91 lbs.

And for the *coke*:

$$\cdot 85 \times 8080 \div \text{latent heat } 537 = \frac{6868 \cdot 000}{537}$$

= Theoretical value in lbs. of water, evaporated by 1 lb. of coke = . . . 12·79 lbs.

Which deducted from the former, leaves . 2·12 lbs.

showing the difference theoretically in favour of the use of coal instead of coke to be equal to 2·12 lbs. of water converted into steam per lb. of fuel.

I have mentioned that if the gases during combustion are not properly mixed with atmospheric air, imperfect combustion must take place; if too little is admitted they will not develop heat in the proper place, but proceed to waste up the chimney; or if the combustion does not take place in the part arranged for in, or under the boiler, you will have the heat going up the chimney, and it will not develop power. I append the table of one or two tests to show you the difference in the pyrometer heat; and as the pressure of the boiler would be 60 lbs. and the temperature of the steam about 350°, whilst the pyrometer heat shows from 600° to 700° for the escaping gases, you may see at once what a loss there is in the mode we adopt in stationary boilers:

Pressure of Steam in Atmospheres	Pressure of Steam in lbs.	Corresponding Temperature
14·6 × 1	14·6	100
1·5	21·9	112
2	29·2	122
2·5	36·5	129
3	43·8	135

Pressure of Steam in Atmospheres.	Pressure of Steam in lbs.	Corresponding Temperature.
14·6 × 3·5	51·1	140·5
4	58·4	145·5
4·5	65·7	149
5	73·0	153
5·5	80·3	157
6	87·6	160
6·5	94·9	163
7	102·2	167
7·5	109·5	169
8	116·8	172
9	141·4	177
10	146·0	182
11	160·6	186
12	175·2	190
13	189·8	194
14	204·4	197
15	219·0	200·5
16	233·6	203
17	248·2	207
18	262·8	209
19	277·4	212
20	292·0	214
21	306·6	217
22	321·2	219
23	335·8	222
24	350·4	224
25	365·0	226
30	438·0	236
35	511·0	245
40	584·0	253
45	657·0	255
50	730·0	266

Mechanical equivalent of heat = the number of foot pounds of mechanical work which must be expended in order to raise the temperature of one pound of water by one degree Fahrenheit degree = 772 = Centigrade $\frac{9}{5} \times 772 = 138{\cdot}6$.

Further, again, we feed the boiler fire with cold air, whereas by proper arrangement for passing the intake air alternately through flues of brickwork arranged with interstices, as in the case of the Whitwell stove, and applied to the heating of the hot blast of the blast furnace for iron, or as in the case of the

Siemens regenerator furnace, we should be able to abstract a very great proportion of the heat which is now wasted.

Look again at the temperature for a moment. You want to raise 60 lbs. steam; this has a temperature of 350° F., the outlet gases go away at 700°, just double. A great saving may be made in this. Then add to the above the enormous power gained by utilising the higher-pressure steam, with but few additional degrees of heat, and you have before you possibilities in engineering economy worthy of continuous effort, as it seems to point to a utilisation of some 50 per cent. instead of 10 to 20 of the coal now used in stationary work.

I can point to the experiments made to burn the small coals by blowing them into the furnace upon incandescent fire as having only realised 30 per cent. of their value as compared with what they should yield under the old evaporative test. You are aware also of Mr. Crampton's patent for grinding coal to dust, and that by allowing it to be blown into chambers or flues which are already heated, the small particles are converted by this heat into gas, and with the mixture of air at once ignite, and combustion ensues just as if they were atoms composing gas rather than coal. One of the first of this apparatus was applied to an ordinary puddling furnace; but the cost of grinding and outlay and other circumstances prevent its application to ordinary fires for boilers &c. at present. Very successful results, however, have been obtained at Woolwich by its use in Mr. Crampton's rotary puddling furnace.

We have much to learn yet as to the best mode to obtain perfect combustion of coal, both in stationary and locomotive engines. An analysis has been made of the gases escaping from locomotives whilst running; and it has been found that too much air has been admitted, the resulting gases varying thus—

CO_2.	CO	O.	N.	
10·5		·8	81·5	black smoke.
12·3		5·2	82·5	white „
12·0	1·5	3·5	83·0	damper closed.

Most of the trials, and they are numerous, show that there is a large excess of oxygen in the combustion chamber, which is caused by the admission of too much air; and thus the oxygen added to excess of nitrogen absorb the heat produced by the combustion of the carbon and oxygen shown in the table. No pyrometer heat in these trials was taken. In the case of stationary boilers it will frequently be found that the amount of CO_2 is very much less than the above proportion, which would represent waste. As a matter of interest and comparison, I annex a table of trials made in the usual way with the same engine and driver, with, as nearly as it could possibly be arranged, the same load over $82\frac{1}{2}$ miles of a straight run on the same ground.

Fuel	Dates		Number of Double Trips run	Miles	Load		Quantity of Fuel			
	From	To			Average of whole journey	Equivalent to 1 Carriage conveyed miles	Cwt.	lbs. per mile	lbs. per carrge. mile	
Welsh Coal,	6th July 1874.	11th July 1874	5	867½	8·4	7,307	163	21·0	2·50	[coal supplied.
Scotch Coal,	29th April 1875	4th May 1875.	5	867½	7·0	6,105	201	25·9	3·68	Cinders produced = 8·06 per cent. of
										Smokebox ashes ·89 „ „
										Solid product total . 8·95
Derbyshire Coal . .	22nd April 1875	27th April 1875	5	867½	7·2	6,251	204	26·3	3·65	Cinders produced . . = 3·65 „ „
										Smokebox ashes . . ·78 „ „
										Solid product total . 4·43
Turf . . .	28th April 1874	1st May 1874 .	7	1214½	7·3	8,903	543	50·1	6·83	[fuel.
„ . . .	15th June 1874	19th June 1874								Solid products, ashpan = 1·864 per cent. of
„ . . .	26th May 1874	1st June 1874 .	5	867½	7·1	6,175	456	58·9	8·27	Smokebox . . . . ·847 „ „
										Total. . . . 2·711
Welsh Coal, No. 1, Monmouthshire	6th May 1875.	12th May 1875	5	867½	7·3	6,359	151	19·5	2·66	Cinders produced . . = 8·61 „ „
										Smokebox ashes . . 1·08 „ „
										Total solid products. 9·69
Welsh Coal, No. 2, Glamorganshire	13th May 1875	19th May 1875	5	867½	7·2	6,282	152	19·6	2·71	Cinders produced . . = 8·84 „ „
										Smokebox ashes . . ·88 „ „
										Total solid products. 9·72 „ „
Derbyshire Coal . .	20th May 1875	26th May 1875	5	867½	7·2	6,237	207	26·7	3·72	Cinders produced . . 5·172 „ „
										Smokebox ashes . . ·845 „ „
										Total solid products. 6·017

You may observe that the Welsh coal is by far the best, and is also proved to be the most economical, but on looking at the ash in this case, you will observe the large proportion of ash, the fact being that the so-called ash was to a large extent an unconsumed coal, which shows an additional point to be observed beyond the gas and pyrometer heat in testing the question as to all the duty possible being obtained from the coal.

It would perhaps appear to you that I am dealing with a question which should rest in the hands of consumers of coals, but it seems to me to point in so many ways to matters of interest to ourselves; for example, the railway companies conveying coal from the North of England to London raised their rates 1*s*. per ton during the coal famine, because of the increased cost of this item in their locomotive charges. You may therefore see that by improved appliances, the result of scientific investigation, it is quite possible to effect such a saving in the consumption of coal, which would be an equivalent to the above charge, and thus enable the trader to obtain a reduction of the rates, and to give an equal or even greater return to the railway companies.

There is the greatest necessity in most departments of trade for the supply of a pure fuel, more particularly in the smelting and manipulation of metals. It is as yet impossible to obtain it in a solid state. We have it provided on a large scale either by the manufacture of what is called coal or hydrocarbon gas, such as the gasworks supply, and by the slow burning of coal to produce CO, which being again burnt, produces carbonic acid CO_2, and thus develops heat; but as about $\frac{1}{4}$th of the heating power of the coal is lost, we are directed to look for a cheap means of producing, not necessarily an illuminating, but a heating gas. We have the means of purifying this gas from injurious ingredients, sulphur &c. Its use in the shape of the so-called natural gas in Pennsylvania proved that there is no difficulty in its application, and the users speak of it as producing results consequent on its purity, which might be anticipated; and I feel

sure that in the smelting of iron for steel, or for the finest metallurgical operations, it will come into use, aided by the gas made by the process adopted by Mr. Siemens, as required for particular operations.

There is another point of importance in the combustion of fuel which deserves attention. It is proved that more intense combustion occurs with a higher development of heat when such combustion takes place under pressure. If you burn a candle at the top of a high mountain, combustion is slower than if burnt at a lower level, where the pressure is more. The American ironmasters work their blast furnaces with a higher pressure of blast than we do ; sometimes working at 9 lbs. on the square inch as compared with ours at $3\frac{1}{2}$ to 4 lbs., and with decidedly greater development of heat. Mr. Bessemer gives us his authority also for believing that this question is in its infancy. Chemists can show you the same fact as occurring in their experience ; but it is a question yet not worked out, and the results, so far as economy is concerned, are unknown.

I would invite some Member, or Members, to give us information on our anthracite deposits ; for it will be evident that this coal, containing as it does the largest amount of fixed carbon, is in truth, on this account, the most valuable. We may overcome the difficulty of its combustion, and also the decrepitation of the fuel when exposed to a red heat, possibly by the use of heated air, as I have suggested, or in some other way. It is more pure than most coals, and remains a mine of wealth only waiting for the energy of engineers to utilise more fully.

I am somewhat afraid of making my remarks on too lengthy a scale, but I may be allowed to say, with regard to the ironstones worked in South Wales, they consist generally of three kinds :

The argillaceous,
Hematite, and
Black band.

The first is costly to get, and yields a low percentage of iron. Many of the workings are closed : other ironstones have supplanted them ; the hematite is as yet proved only in a compara-

tively small district, and is limited in quantity; the black band local. None of these suffice, either from richness, or cheapness, or quantity, to satisfy our district want.

Our nearest mines are those of Somerset, Devon, and Cornwall. Many of these ores are not to be used, from their intermixture with phosphorus, sulphur, arsenic, &c. We have imported large quantities of good ore from North Spain and other places. It is expensive and sometimes difficult to get.

I venture to point out that the chemists of the iron works may enter on a field of research in the utilisation of many of the rejected ores from the following results accomplished by the Tharsis Sulphur Co., who import the sulphate of iron from Helva, in Spain, burn out the sulphur, and utilise it in the shape of sulphuric acid; treat the residuum for copper and for silver by a beautiful process by means of the Gramme's galvanic battery; and it is said, in a paper read before the Society of Arts, that the silver pays for the process. We have as yet scarcely troubled ourselves in the way of research at the ironworks beyond ascertaining the units of iron the ore contains; but supposing the chemical knowledge of the day points to the extraction of the rarer metals, many of which are associated to a large degree with both phosphorus and sulphur, we may imagine that our near iron ore fields in Cornwall and Devon will become of service; science render to our country the service it has hitherto done in combination with industry, and keep us yet in the advanced rank of nations and peoples in this respect, and give to South Wales a yet more abiding development.

With regard to the iron manufacture, I feel I should be entering on too large a field of inquiry at the moment, but I may say, with coal and ironstone delivered at a cheap rate, I feel sure our Welsh ironmasters will not be behindhand in the manufacture of either iron or steel; and I do think that South Wales, with the copper manufacture, the silver extraction, will find her sons ready and prepared to work out the results satisfactorily.

Mr. BEDLINGTON had much pleasure in proposing a vote of thanks to the President for his very able Address, and although it was not usual to discuss the matters touched upon in addresses of that character, yet many of the Members, no doubt, felt a strong inclination to do so, seeing the wide field over which it had travelled, and the numerous subjects of practical interest which had been brought to their notice.

Mr. ALEX. BASSETT, in cordially seconding the proposition, considered that the President's Address was one of the most exhaustive that had been delivered before the Institute, and could not fail to be of real practical use in directing the attention of Members to the various topics he had touched upon.

A vote of thanks was then unanimously accorded to the President for his able Address.

The Discussion of Papers read at previous Meetings was then proceeded with.

ADJOURNED DISCUSSION ON "THE DIAMOND DRILL."

The PRESIDENT said their first business was to resume the discussion of Mr. Bassett's Paper on "the Diamond Drill," and of Mr. Huxham's Paper on "Some Particulars of Boring with the Diamond Drill," which Papers were taken together at the last Meeting, and adjourned for further discussion; he should have much pleasure in hearing the remarks of any of the Members.

Mr. ALEX. BASSETT was sorry he had not been able to be present at the last Meeting, but he had since had the opportunity of reading the remarks that were made on that occasion, and he thought a very important and interesting discussion had taken place, he considered the remarks then made by Mr. M'Murtrie were exceedingly interesting. He had nothing more to add to the statements contained in his Paper, which was simply a record

of dry facts that had occurred in that district. He agreed with Mr. Adams as to the difficulties which arose from the bore-holes being generally started of too small diameter, and thought an improvement should be made in that direction. It was also desirable that too great a speed should not be attempted in boring, when the special object was to procure an accurate section of the strata passed through.

Mr. HENRY K. JORDAN considered that Mr. Huxham had done the Institute good service in bringing forward his Paper on that subject. He thought that two lessons were to be learnt from it, which should be impressed on those conducting similar operations. The first was, that in all cases it was very desirable, where practicable, to commence the bore-hole in the solid strata; and second, that the bore-hole should be started of larger diameter. He considered it one of the greatest drawbacks to the use of the Diamond Drill, that a good core was very rarely obtained in friable strata, which was probably due to the attrition of the boring rods, and to the erosive action of the water sent down the tubes for clearing away the *débris* at the bottom of the hole. If the diameter of the bore-hole were enlarged, no doubt there would be a greater chance of bringing up better cores in soft ground. He thought the value of the Paper would be found in the practical lessons it inculcated, and which would prove of much service in future operations. When everything went on smoothly and successfully, they were apt to take no notice; and when, as in the case recorded by Mr. Huxham, difficulties arose and results were unsatisfactory, few had the courage, or cared, to record unsuccessful experiences, although such were generally of the greatest practical importance.

The PRESIDENT thought it was almost impossible always to commence a bore-hole in the solid strata; where practicable, however, it was no doubt advantageous to do so. Probably much of the loss that had arisen in every shape in conducting boring operations might have been remedied more easily if the bore-holes had been started of larger diameter, but that neces-

sarily added considerably to the cost. He thought they had elicited much information in discussion, and that the same might now be brought to a close.

The discussion on the two Papers was accordingly closed.

ADJOURNED DISCUSSION ON "BLOWERS AND OUTBURSTS OF GAS."

The PRESIDENT said that the next subject for discussion was Mr. George Wilkinson's Paper on "Blowers and Outbursts of Gas." He remarked that the subject was one of great interest to the Institute, and more particularly so in this case, as the Paper was the practical experience of a thoroughly practical man in some of the most fiery collieries of the South Wales District. It was well known that the effective and proper drainage of the gas from any colliery district, or coal-working, exercised a most beneficial influence on the cost of production, inasmuch as the gas when first tapped was a powerful agent in breaking down the roof, and otherwise rendering the cost of repairs and maintenance very heavy. But when the bulk of the gas had in the first place been judiciously drained away, and its energy had been thus spent, before the working away of the coal in any quantity was attempted, it was found that a very considerable saving was effected in the cost of repair and maintenance, and he thought Mr. Wilkinson had done good service in directing attention to the evils brought about by the defective drainage of both gas and water.

Mr. GEORGE WILKINSON said he had been asked at the last meeting if he had found that the "Four-feet" seam of coal produced more gas than any other. He thought, as a rule, that it did; but a good deal depended upon which seam of coal was first opened, and the distance between that and the other seams. He had worked the "Four-feet," when it gave out three times as much gas as any other seam, but he thought that arose more particularly from the additional influx of gas from the "Two-feet-nine," lying above the "Four-feet." He had opened the

"Four-feet" in many instances, and in every case, except one, with a similar result. In that one case he had opened the "Six-feet" seam first, the "Four-feet" not having been worked, and he had been troubled with gas just as badly as if he had been opening the "Four-feet." That, he thought, showed that the larger quantity of gas would generally be met with in whichever seam of coal was opened first, as the workings then acted as a drain to tap and carry off the larger proportion of gas in the strata and accompanying seams. It had been suggested that by first opening in the "Two-feet-nine" it would drain the gas from the "Four-feet," and he thought that that would be the natural result; but in that event the "Two-feet-nine" would probably be as troublesome to work as the "Four-feet," and little or no gain would result. He found that in working the "Two-feet-nine" over where the "Four-feet" had been previously extracted, but little or no gas was generally met with; and the same held good in a greater or lesser degree with all the seams in that district.

Mr. Henry K. Jordan asked whether it was probable that the gases of the coal measures, when under very great tension or pressure, existed in a liquid state, in the same manner as carbonic acid gas was known to liquify under great pressure?

The President said it had been discovered that certain gases, under enormous pressure or intense cold, tend to solidify. The natural gases of a coal mine consist of carbonic acid (which might be solidified), or hydrocarbons, which had never yet been reduced to a solid state. He thought, amongst other matters touched upon by Mr. Wilkinson in his Paper, that the subject of "compressed air," in connection with underground haulage, was very important, and that compressed air was destined to supersede the use of steam, and also of horses, to a great extent, for underground haulage in large collieries.

A Member said that he had experienced some difficulty in the use of compressed air from the formation of ice, which they hardly knew how to remedy, until they put a small pipe into the

delivery main, and allowed a small stream of water to pass regularly over the piston, and since that they had no difficulty with the formation of ice.

Mr. SNAPE said that in one case ice had formed in the pipes, which was found to have arisen from a leak in the air pipes, and water had got in with the compressed air, and that created a difficulty by causing ice to form at the exhaust; but where the pipes were sound, and the air tolerably dry, they experienced no difficulty from ice, and had engines pumping continually with compressed air. He might mention, however, that it was desirable to put the valve as near the exhaust as possible, so as to have no intermediate length of pipe.

The PRESIDENT thought it would be of service if some of the members, who had used compressed air to some extent, would give their experience as to the economical work utilised, in comparison to the engine power first applied in compressing the air. His impression was that as much as 30 per cent. of useful power was lost in the absolute work of compression, in friction, &c.: that is, that the power evolved from the compressed air, at (say) a mile distant from the compressing power, was 30 per cent. below the power exerted in compressing and forcing the air to that extreme point.

Mr. COLQUHOUN asked whether that meant that 70 per cent. of the compressing power had been utilised from the compressed air in the mine? for he had been told the other day, by an engineer connected with the largest works in the country, that the useful effect was only 25 per cent.

The PRESIDENT spoke only from recollection, and it was possible he had reversed the figures.

Mr. BARROW said that the President was right in the first instance, and had correctly stated the result of their experience in the use of compressed air; that is, that the compressed air as it leaves the compressing cylinder will give out 70 per cent. of the steam power expended in the compression; but when it was conveyed a mile away, they found the economical power, or useful effect,

then developed, was reduced to 25 per cent. of the power exerted by the compressing engine. But still it was a question whether it was not the best power that they could use, when a comparison was fairly made with the great loss of power, from friction &c., which arose in the systems of rope haulage now so much in vogue.

Mr. A. J. STEVENS said that a short time ago he worked out the theoretical loss of power, but it depended considerably upon the form of engine used for compressing the air. If an ordinary winding engine were used, the loss would be very considerable; but taking a compressing engine of good form, cutting off at 3/8ths, and condensing, he had worked out the theoretical power utilised from the compressed air underground, and found that it could not exceed 30 per cent.

Mr. BARROW said that no doubt a great deal depended upon the class of engine used for compressing. He thought that the highest description of engine should be used for that purpose; and he had seen in Lancashire as good an engine for that work as could be made, and in Durham also he had seen excellent engines for the purpose. He thought it was very desirable to use double-cylinder engines, and well balanced, admitting of regular and perfect action.

The PRESIDENT said, if he remembered correctly, a steam-engine of good form would utilise or give out about 70 per cent. of useful effect. Supposing that such an engine compressed air to 50 lbs., and after the compressed air was conveyed underground to the workings, it was found it still indicated a pressure of 50 lbs. and upwards (as was frequently the case in practice), he was at a loss to understand why only 25 to 30 per cent. of the original compressing power could then be developed. In conveying steam underground it was well known that condensation took place, and the pressure fell with much loss of useful effect, whilst, on the contrary, with compressed air, no condensation took place, and the pressure was maintained, and even found to be increased at the extremity of the workings.

Mr. A. J. STEVENS thought that the loss referred to arose

between the compressing engine and the air-consuming engine underground, and was the loss incurred in conveying air instead of steam.

Mr. Barrow remembered that he had diagrams of a compressing engine at Ryhope, where an equal power was indicated by the compressed air as that exerted in the steam cylinders, and he should be happy to show these diagrams to any member. In that case the power developed in the compressing cylinder was equal to that of the steam used in the steam cylinder.

Mr. Colquhoun said that similar results might be obtained in many cases, but he did not think that it affected the question of the amount of useful effect to be developed by the air at the air-consuming engine underground.

Mr. Bassett thought it was important to determine the difference in the indicated pressure of a column of compressed air in the pipes on the surface, and when it had reached the bottom of the pit, or other place where it was consumed underground.

Mr. Barrow said that he had found that the compressed air indicated an increased pressure of 7 lbs., when taken 500 yards down the pit to the underground air engine, in pipes 9 ins. in diameter. He had caused the pressure gauges to be reversed, so as to be certain that the results were correct.

Mr. Snape said the question of the loss arising in the use of compressed air for transmitting power to a distance had frequently been raised, but had not been settled in a satisfactory manner. They had recently put up a powerful plant for compressing air, comprising 34-in. steam cylinders, and 40-in. air cylinders, by 6 feet stroke; the engines being fitted with variable expansion gear. They were now at work, and in a position where they could be seen by the members, and he should have much pleasure in allowing as many gentlemen as pleased to inspect the same and make any tests they thought desirable to ascertain the precise duty developed by these compressors, and to determine the loss from thence to the underground air engines.

Mr. COLQUHOUN said that the matter under consideration had been discussed over and over again in other places, but it appeared that there was great diversity of opinion, and no small amount of theory. The fact, however, apparently remained that only about 25 per cent. of the original power was developed at the air-consuming engines. He had machinery to put up, and had intended using some of Mr. Stevens' compact small air engines for hauling purposes underground, but the practical results, and loss of power in the use of compressed air, induced him to defer doing so until better results were obtained. He was quite sure that there must be something wrong with the engines or other parts of arrangements, when no more than 25 per cent. of the motive power was utilised. He considered that they should accept Mr. Snape's invitation to test the fine compressing plant which he had recently erected, and make a series of careful experiments to arrive at correct results, and determine where and in what manner such a loss of power arose. He had observed that Mr. Wilkinson in his Paper had stated that the smaller of two pits standing on the same level always acted as the upcast, and he understood Mr. Wilkinson to say that that was so in every case, and also in sinking pits; he, however, could only say that that was not in accordance with his experience of fifty or more sinking pits. He thought that the success of the method adopted by Mr. Wilkinson in restoring the current to the upcast shaft after it had been reversed, by first closing the top and afterwards opening the same very gradually, might be explained on other grounds. It would be remembered that in the case Mr. Wilkinson referred to, an outburst of gas had taken place, and from a strong wind beating down the upcast, the current had been reversed. Of course the first thing that was done was to stop the air going down the upcast by covering the top of the shaft. At that time the sides of the upcast shaft still retained much of its accustomed heat from the ventilating furnace, and was no doubt considerably warmer than the downcast; as soon therefore as the down current was stopped

by closing the top, the air in the shaft became heated, and was ready to ascend through the first opening, so that when a small opening was first made it naturally came out, and as the size of the opening was increased it flowed in greater volume, so that the current was soon restored to its original channel.

Mr. C. H. James remarked that at the last meeting he had referred Mr. Wilkinson to a Paper by Mr. Hall, and asked him whether he agreed with the statement there made, that it was better to use the smaller shaft for the downcast, and the larger one for the upcast, and if not, whether he could give any reason for preferring the smaller shaft for the upcast, bearing in mind the expansion of the return air by the heat.

Mr. Wilkinson said that Mr. Colquhoun was undoubtedly correct in saying that the upcast pit at Abernantygroes was still warm after the reversal of the air, but, quite independently of that, he would have followed the same course had the pit been quite cold, because his experience had always been that the smallest pit became the upcast, where there was no artificial ventilating power. He stated, as a practical man, that it was always easier to get a current of air through an upcast shaft when it was of smaller area than the downcast, but he acknowledged that he could not give a satisfactory explanation of the fact.

Mr. C. H. James had stated at the last meeting that the smaller pit had a larger periphery, or heating surface, in proportion to its cubical capacity than the larger one; and as the strata in all pits gave out a certain amount of heat, the air in the smaller pit would be heated more rapidly than in the larger, and thus an upward current would be induced in it.

Mr. Colquhoun thought it should not be forgotten that where an upcast pit was contracted in area to one-half that of the downcast, the air must travel at double the velocity, and that there would consequently be four times the amount of friction. The general practice, however, was to have the upcast pit one-third less in area than the downcast.

Mr. Hugh Begg said that in practice they found it preferable

to have a small shaft for the upcast. He did not think the reason adduced by Mr. James was the correct solution. If the temperature of the strata in the upcast pit were uniform, it would probably heat the air in winter, but cool it in summer, and thus the smaller shaft would become an upcast in winter and a downcast in summer. He did not think the practical fact of the smaller pit becoming the upcast was explained by the air absorbing the natural heat of the strata. He thought it was generally conceded by all who wrote on the subject that the smaller shaft invariably became the upcast.

Mr. DAVID THOMAS was at a loss to account for the smaller shaft becoming the upcast as stated by Mr. Wilkinson, because when a volume of air is contracted, or compressed into a smaller area, a certain amount of power is absorbed in the increased friction. He thought the circumstances of each case should be fully and clearly stated, giving the comparative size, temperature of air in shaft, state of the sides, whether walled or not, and whether wet or dry, of each pit. In sinking pits he was well aware that a certain amount of circulation was often visible, and that there were natural up and down currents of air often produced in the same pit.

Mr. COLQUHOUN said that Mr. Wilkinson had stated, as a general principle, that in every case, so far as his experience went, the smallest shaft became the upcast, and it would be very desirable to have some satisfactory explanation given to them of that circumstance.

Mr. BEDLINGTON said that there must be some other circumstances, and that it was not due to the smaller area of the pit.

Mr. COLQUHOUN thought that it would be well to adjourn the discussion, so as to give full opportunity for further considering one of the most important practical Papers that had been read before the Institute.

Mr. DAVID THOMAS concurred in that view, as he thought Mr. Wilkinson's Paper required considerable study and further

discussion, to elucidate all the points clearly. Referring again to the statement of the smaller pit invariably becoming the upcast, he thought it was of considerable importance that the reason should be satisfactorily explained by those who supported such a proposition.

The PRESIDENT said that he quite agreed that Mr. Wilkinson's Paper contained many points of great practical importance, and that it would be better to adjourn the further discussion to the next meeting, as they had other business to dispose of.

The discussion was unanimously adjourned to the next meeting.

DISCUSSION ON THE "PENCOED, MYNYDD-Y-GAER, AND GILVACH GOCH MINERAL DISTRICTS."

The PRESIDENT was afraid their time was very short to open a discussion on Mr. Henry K. Jordan's very able and valuable Paper; but nevertheless he should be glad to hear any remarks that members had to make.

Mr. HENRY K. JORDAN said that his Paper was the result of investigations extending over a long series of years, and the opinions which he had expressed were not hastily formed, but were conclusions arrived at after mature investigation, and he therefore had great confidence in their correctness; but, nevertheless, as conclusions were sometimes based on erroneous views, or misconception of facts, he asked for the fullest possible discussion of his Paper, so as to thoroughly elucidate all points bearing on the subject.

Mr. DAVID THOMAS took exception to the statements made by Mr. Jordan at page 268, where he says that "The true anticlinal axis was near the Margam Tin Works, almost a mile further south" than the position assigned to it in the Paper which he (Mr. Thomas) had read on the "Afon Valley Mineral District" some time since; and he would like to know what proof Mr. Jordan had that his statement was correct. He was

aware that anyone passing along the road from Aberavon, up the Afon Valley, might observe, at a point about 300 yards north of the town, that the strata rolled over to the north-east; he said, however, that that was a local roll, which he thought was proved, by the crop of the Goitre seam, which could be followed from near the Margam Tin Works, round the hill to the Duffryn, where extensive openings were being made on it; and from the mouth of that valley, the crop of the same seam could be traced along the side of the mountain to Margam; but if the Anticlinal axis passed in the line indicated by Mr. Jordan, the outcrop of the Goitre seam would not be found in that position, for the strata in that case would have taken another dip, whereas the stratification was undisturbed, and could be seen the greater part of the distance from Aberavon, dipping about 9-ins. on the yard to the Anticlinal, which had been most distinctly proved to run from Baglan, through Cwmavon, up to Oakwood, Bryn, and Llynfi. If Mr. Jordan could trace the Anticlinal in the course that he had assumed it to run, from Baglan towards Llynfi, he would be glad to follow him, and point out, first, that no fault existed at Baglan except the one—as he had stated in his Paper—that runs parallel with the Anticlinal Line from Baglan to Cwmavon; and he had previously explained that at that point the Anticlinal throws down the Wernddu seam, which crops out at the highest point of the hill, to the north of Cwmavon; and had accounted for it by saying that, in addition to the Anticlinal, there was an accompanying fault which caused the displacement. That fault was to be distinctly seen on the south side of the Cwmavon Works, together with 30 or 40 yards of the strata on the Anticlinal Line, so that all the stratification from those works eastward was undisturbed. He thought, therefore, that Mr. Jordan's assumed Anticlinal Line, at that point, was only a local roll, which ceased before it reached Duffryn, or else the crop of the Goitre seam could not be traced as far as Bryndu. He could prove that the position he had assigned to the Anticlinal from Baglan to Llynfi was correct.

Mr. Hugh Begg considered that Mr. Jordan had made a mistake in taking 90 yards as the normal distance between "No. 2" and "No. 3 Rhondda" seams, for in no case had he known it to exceed 80 yards. The distance between these seams, sunk through at Llwynypia, was 75 yards; at Upper Dinas, 79 yards; at the Great Western, 68 yards; at Coedcae, 72 yards 2 feet; and he thought at other collieries the distance was something less. If the "Forest Fach" was, as he believed, the "No. 2 Rhondda," the distance was nearly the same throughout the Rhondda Valley. The "Three Coals" lie about 8 yards under the "No. 3." He observed that Mr. Jordan had marked on his plan the probable position of two faults running through Mynydd Pen-y-Graig, one of 65 yards and the other 85 yards, both upthrows to the north-east. The existence of the Cwm Clydach fault, passing south-westwards of Penygraig Colliery, was well known, but he did not think that the other two faults suggested by Mr. Jordan existed at all, for the crop of the "No. 2" seam could be traced very regularly round the hill side. At the northern extremity of the longitudinal section, given in Plate 30, Mr. Jordan shows the Llwynypia Pit, as having been sunk through the "No. 2" and "No. 3" Rhondda, and the "Abergoci" seams, down to the "Six Feet" coal; and also shows the "Lower Four Feet" and "Garw" seams to underlie the bottom of the pit. He should be much obliged if Mr. Jordan would correlate those veins, as far as he could, with those of the Rhondda and Aberdare Steam Coal districts. In respect to the "Glynogwr" veins, he was inclined to think that they underlay the "Llantwits." They came to light at Tydu, one cropping out at the surface, with a good distinct section, the other some 60 yards below, going away towards Hendreforgan. It appeared to him that the vein opened there, and a seam opened at a colliery called Caradog, was the same as that opened upon at Glynogwr, and also identical with the vein that crops out at Bettws, 4 to 5 miles further to the west.

Time prevented the further discussion of this Paper, which was accordingly adjourned to the next meeting.

The PRESIDENT said that they had been so fully occupied in discussion of the various Papers, that their time had run too short to open a discussion on Mr. Bassett's Paper on "The Drainage of the Taff Vale District," which would have to stand adjourned to the next meeting.

In respect to Mr. George Birbeck's Paper on "The Bryncethin and Ogmore Mineral District," and Mr. George Wilkinson's Paper on "Colliery Explosions," they could not do better than follow the usual course under such circumstances, and take them as read, so that they may be printed in the next Number of the Proceedings.

A vote of thanks to the President closed the proceedings.

THE BRYNCETHIN AND OGMORE VALLEY MINERAL DISTRICTS.

By Mr. George Birbeck.

This Paper is intended to form a connecting link to Papers previously read before the Institute, on the Neath, Afon Valley, and the Llynvi Valley District, to the West of the Ogmore Valley, and that by Mr. Henry K. Jordan, on the Pencoed, Mynydd-y-Gaer, and Gilfach Coch District, lying to the east.

It is not the intention to attempt to advance any new theories, having reference to this District, but merely to confine the observations to a general description of the Seams of Coal, Faults, and other general mining features, with as much accuracy as the knowledge obtained from its present very limited development and recent explorations will permit.

The Area embraced in this Paper (including the District lying between the Ogmore and Garw Rivers) has not been developed to any great extent, although ample Railway facilities have existed on the Ogmore side, for some ten years. On the Garw side, a Branch Railway has been recently constructed to the head of the Garw Valley, but up to the present time it has carried but a slight traffic, due in a great measure to the depressed condition of the Coal trade, that commenced a short time after the Line was opened, and which has kept the development of the Valley in abeyance.

Touching briefly on the extent of development of this District, it may be stated that at Bryncethin, on the South crop, the

Barrow Steel and Iron Company are sinking three large Pits to the lower measures, and which are down at present 259 yards, having intersected the Seams of Coal as shown in the Section, Plate 4. These Pits are sunk near to the New Cardiff and Ogmore Railway, which will give them ready communication with Cardiff and the other ports. The machinery and general arrangements in connection with these pits are being carried out and finished in a very excellent and substantial manner, and having extensive Royalties, containing all the "South Crop" measures, this will in a few years be a very large and important Colliery.

West from Bryncethin, between that place and Tondû, the Ynisawdre Coal Company have also sunk down to the Lower "South Crop" measures.

Proceeding North, the little Bettws Coal has been worked in the Brynwrach Common, lying to the South of Llangeinor Church, by means of shallow pits and free drainage Levels. This Vein has also been worked at the Bettws Colliery, on the Western side of the Garw Valley.

A Diamond Drill Borehole was put down 600 feet by the Bettws Llantwit Colliery Company, near to the Garw River, commencing a little below the outcrop of the little Bettws Vein, in hopes of proving the existence of the "Nine Feet" Bettws Vein, but without success.

In the Garw Valley and North of the Moelgilaû Fault, a pair of Pits have been sunk by the Llest Colliery Company, with a view to intersect the "No. 2 Rhondda" Seam; one of the Pits is at present 80 yards in depth, and the "No. 2" Seam of Coal is expected to be reached at a further depth of 40 yards. It may be remarked (although outside of the strict limits of the area taken up in this Paper) that the "No. 2" and "No. 3 Rhondda" Seams have been worked on the Braich-y-Cymmer estate, adjoining the "Llest" property, on the West side of the Garw River, by Messrs. Miller, Sons & Co., by free drainage Levels, and also on an adjoining property by the West Rhondda Coal Company.

Further North, the "No. 2" and "No. 3 Rhondda" Seams have been worked by the Messrs. Brogden, by Levels at Forch-wen, and "No. 3" has been worked at Nant-hir.

In the Ogmore Valley the "No. 3 Rhondda" Seam is being worked at Tynewydd, and the "No. 2" at Fron Wen, by Levels, and the latter has been connected by level with the workings from the Garw side at Forch-wen. The "No. 2 Rhondda" is also being worked on the East side of the Ogmore Valley by the Aber Coal Company, and farther North the "No. 2" and "No. 3" have been opened out by Levels at Nantymoel, near the head of the Valley.

A pair of Pits have been sunk by the Messrs. Brogden, down to the "Two Feet Nine" and "Four Feet" Seams, as shown in Section, Plate 5.

Another pair of Pits have also been sunk, north of the Wyndham Pits on the east side of the Valley, by Mr. Davis, and have intersected the "Two Feet Nine" and "Four Feet" Veins, at the respective depths of 264 and 334 yards.

It must be considered that the Ogmore and the Garw Valleys have a very important future, forming, as they do, one of the most valuable mineral tracts in the South Wales Coal Field. The only Seams that have been worked, to any extent, are the "No. 2" and "No. 3 Rhondda," and to a smaller degree the "Two Feet Nine" and "Four Feet" veins, thus leaving practically untouched the valuable lower Steam Coal measures, which will have to be won by pits.

The following Plan and Sections have been prepared to illustrate the District referred to in this Paper, viz.:—

Plate 1. A Plan of the District lying between Bryncethin on the South, and Nantymoel on the North, showing the direction of all known faults, outcrops of Coal, and other general surface features.

Plate. 2. A Horizontal Section, from the outcrop of the "Crow's Foot Vein," (the lowest of the South Crop measures), crossing the Ogmore Valley River about half a mile above

Brynminen Village, and from thence over Mynydd Llangeinor to Nanty Moel Brook, as shown on the Plan (Plate 1), from A to B.

Plate 3. A Vertical Section of the South Crop measures.

Plate 4. A Vertical Section of the Strata sunk through at Bryncethin Colliery.

Plate 5. A Vertical Section of the measures North of the Moelgilaû Fault.

Plate 6. A Vertical Section of Ynysawdre Pit.

DESCRIPTION OF THE FAULTS.

The general directions of the Faults of this District are shown on the Plan (Plate 1).

The first known Fault of any importance crossed by the line of Section, is the one known locally as the *Moelgilau Fault*, which forms the dividing line of this District, between the Southern and Northern series of Coal measures. Its general direction and magnitude at various points have been described in the papers referred to previously, although it may be remarked that on the question of its dimensions, a very marked difference of opinion exists.

In attempting to arrive at the size of the Fault, the conclusions here stated are based on the supposition that the "Rock Vawr" Seam of the South Crop measures is identical with the "No. 3 Rhondda" Vein, belonging to the series North of the Fault.

The writer has long considered this question, and more recent and careful investigation, comparison, and research only confirmed the opinion, arrived at some years ago, that the two Coals above mentioned are the same.

There is certainly a great dissimilarity in the general appearance, and also the quality of the two veins, but this cannot be considered by any means a fatal objection to the theory, as it is well known that this and other seams are locally affected in quality

and section. In arriving at the dimensions of this Fault, and assuming that the "Rock Vawr" and "No. 3 Rhondda" to be identical, the writer estimates it to be an Upthrow Fault north, of about 250 yards.

Proceeding Northwards, the next Fault met with is one that the writer has named the *Caedû Fault*, an end section of which is exposed in a cutting in the narrow gauge Locomotive Line, leading from Forch Wen Levels to the top of the Caedû old incline. This Fault was also met with near the mouth of the Level on the "No. 2 Rhondda" seam, near the same place. It is a Downthrow south, but its extent has not yet been proved. The inclination of the measures South from this Fault is very considerable for some distance, amounting in some places to as much as 10 inches in the yard, which may explain the position of "No. 2" seam, in the lower part of the Braich-y-Cymmer property, and also the depth at which it is proved in the Diamond Borehole at Caedû.

The line of Section next crosses the *Nant-Hir Fault*, found at the face of the Level on the "No. 3" seam at, or near, Nant-Hir, in the Garw Valley. This Fault is a Downthrow North-east; its precise dimensions have not, however, been proved, although an attempt was made to prove its extent by driving down at the face of the Level, in the lead of the Fault, for a depth of upwards of 30 yards, but without success. This Fault runs in an oblique direction through Mynydd Llangeinor, crossing the Ogmore Valley between Tynewydd and the Aber Level, on the east side of the Valley. As a confirmation of the range of this Fault, there is a fine section of the dislocation in the rocks, exposed near the summit of Mynydd Llangeinor, at point marked **D** on the Plan (Plate 1). This line of direction produced from Nant-Hir through the point **D**, will show the line of the Fault to run, as already stated, between Tynewydd and the Aber Level, and will account (as referred to in Mr. Henry K. Jordan's Paper) for the difference existing in the level of "No. 2 Rhondda" Vein on each side of the Valley; this difference of

level between the two places proving the Fault to be a Downthrow North-east of about 80 yards at that point.

In further corroboration, a Fault was met with near the mouth of the Fron Wen Level, in the "No. 3" Seam, and there can be little doubt as to its identity with the Nant-Hir Fault. From the general direction of this Fault, and its being a Downthrow North-east, it is in all probability identical with the Church Fault referred to by Mr. Jordan.

The next Fault Northwards is a Fault met with in the face of the Level on the "No. 3" Vein at Nantymoel, and named, for the sake of identity, the *Nantymoel Fault.* Explorations to prove the magnitude of this Fault were made from the face of the Level for a depth of 30 yards, but without satisfactory results. The distance between this and the Nant-Hir Fault is about 660 yards. If the inclination of the strata between these Faults be the same as it is on the North and South sides of the Trough, and is also free from disturbance, the Nantymoel Fault is an Upthrow North of 120 yards. This Fault has not been traced Eastwards, but a Fault has been struck in the workings from the Wyndham Pit which may prove to be the one under notice; but in the absence of further evidence it would not be well to say anything more definite on the subject. It may, however, be added, that from the direction and magnitude of this Fault it may probably be the Glyncorrwg Fault, or a branch from it. Another Fault is generally supposed to exist at the head of the Garw Valley, and leads Northwards in the direction of the Avon Vale, and by some is supposed to be the *Glyncorrwg Fault.* There is unmistakable evidence of the existence of a Fault at the point named, as shown by the difference of level existing between the "No. 2" Coal on the Eastern and Western sides of the Valley. There is no evidence, however, as to its magnitude and direction Southward.

The *Horizontal Section* (Plate 2) commences at the outcrop of the "Crow's Foot" Vein of Coal, south of Bryncethin Village, and includes the whole of the South Crop Veins to the Moelgilaû

Fault. On the North side of the same Fault the northern series are carried on to the end of the Section, terminating at the Nantymoel Brook. The thickness of the strata at the Synclinal is 1770 yards, but a little farther north the Moelgilaû Fault throws out the Bettws Vein, and consequently the aggregate thickness of the strata on the North side of the Fault is greatly reduced.

The minor Anticlinal (described in Mr. Jordan's Paper) does not, according to the present evidence, materially affect the ground in this line of section, excepting, perhaps, to render the inclination somewhat less; but eastwards, in the Ogmore, near New Mill, the strata are much confused, and in a series of waves.

The measures at Bryncethin are inclined at an angle of 46°. This sharp angle, however, gradually diminishes. At Brynmenin it is not more than 24°; and further North, at a Quarry recently opened in the Bryn-Wrach Common, the inclination is 7½°, and continues to decrease down to the Synclinal Line, where the strata begins to rise Northwards to the Moelgilaû Fault.

On the North side of the Moelgilaû Fault, it will be seen on reference to the Section, that the strata rise Northwards at a sharp angle for a short distance, and then run out at an easier angle up to an imaginary line, extending across Mynydd Llangeinor, from a little south of Caedû in the Ogmore Valley, to a little south of the Llest Pits in the Garw Valley. From thence the strata commence to run with a sharper angle to the Caedû Fault, North of which they take the usual inclination of about four inches in the yard, up to the Anticlinal Ridge, at which point there is no disturbance, but the strata gently turn over the Ridge, and continue with a reverse dip Northwards, at about the same inclination, and continue in all probability, with the exception of the Nant-Hir and Nanty-Moel Faults, unbroken to the limits referred to in this Paper.

The workings in the "No. 2 Rhondda," which have been extended over the Anticlinal, have proved the ground on the Ridge

to be practically level, and the Coal retains its full section, but merely changes its dip Northwards.

The *Vertical Section* (Plate 3) shows the thickness of the measures lying South of the Moelgilaû Fault. The most valuable Seams in this Series are the "Bettws Four Feet," "Rock Vawr," "Boddwr Vawr," "North Vawr," "South Vawr," "Six Foot," "Nine Foot," and the "Cribbwr Vawr." With the exception of the "Rock Vawr," all the above Seams are of a bituminous character, and the Coke produced from them is of excellent quality, being remarkably free from sulphur. The Coals generally are of a tender nature, and do not yield more than about 40 per cent. of large Coal.

In touching on the special qualities of the above-mentioned Coals, it will be better to take them in the order named above.

The *Bettws Four Feet* is of an average thickness of 4 feet, with a fair roof and floor. It makes an excellent House Coal, and although not so highly bituminous as some of the lower measures, yet the Coke produced from it is of fair average quality.

The *Rock Vawr* Coal is of an average thickness of about 3 feet, with a good Rock top and Fire-clay bottom. The Coal is rather tender, but is an excellent Steam Coal, more especially for stationary engines. The Fire-clay underlying this Coal produces very good Fire-bricks.

The *Boddwr Vawr* gives an average thickness of about 8 feet of Coal, and has a fair shale roof, but an inferior soft Clay floor. The Coal is of a very tender nature, and yields a very large percentage of small Coal. The Coke produced from the "Boddwr Vawr" is of great purity and excellence, and has the best reputation for the manufacture of Iron.

The *North Vawr* Coal varies in thickness from 8 to 20 feet; the roof consists of Shale of a tender nature, and Stratified beds of Ironstone; the floor is a mixture of tender Shale and "rashings;" the Coal is very friable, and consequently yields only a small percentage of large Coal. It is a very good House and Steam Coal, and is well adapted for manufacturing purposes.

When this Coal is washed, the Coke produced from it is of the first quality for general purposes.

The *South Vawr* is about 4 feet thick, with a strong Shale roof, and a floor of very soft Clay. It is a fairly hard Coal, and is of good quality for household and general purposes. It is also a good Coking Coal.

The *Six Foot* is of an average thickness of 5 feet, and has a roof of strong Shale, and a hard Fire-clay floor. The Coal is hard, and returning a fair percentage of large; a good House Coal, and yields good Coke for general purposes.

The *Nine Foot Vein* is about 6 feet thick, and has a Shale top, and a Fire-clay floor. The Coal is of an inferior quality, compared with the above-mentioned seams.

The *Cribbwr Vawr* has a good Shale roof, and a hard Fire-clay bottom, and is of an average thickness of 5 feet. This seam is undoubtedly the most valuable of the South Crop Series for general purposes, especially for its qualities as a House Coal, being superior in that respect to any seam in this Coal Field. It is also a first-class Coking and Steam Coal. The Fire-clay underlying the Coal is of a variable character; in some districts it has been found valuable for brick-making, but in others it is comparatively valueless.

There are several beds of *Ironstone* lying between the "Boddwr" and the "Cribbwr Vach" seams, which have been chiefly worked by patching, or open work. This mode of working proved very expensive, and has in a great many cases been abandoned on that account.

The *Vertical Section* (Plate 4) contains the Seams lying north of the Moelgilaû Fault, which are so generally well known that I do not consider it necessary to enlarge upon them. It may, however, be remarked that the "Two Feet Nine," and the "Four Feet," seams worked at the Wyndham Pits, are of a highly bituminous character, and produce a Coke of great purity and excellence. Another question of interest that I may mention is the remarkable difference existing in the Section of the "No. 2 Rhondda," as worked by the Llynvi, Tondû, and Ogmore Coal

and Iron Company on the West side of the Ogmore Valley, and that worked by the Aber Coal Company on the East side of the Valley, as shown in the following sections, viz. :—

CAEDÛ COLLIERY.

Section of "No. 2 Rhondda."

Strong Shale Top.

	Ft.	in.
Coal	3	4
Rashes	1	6
Coal	0	10
	5	8

Bastard Rock Bottom.

ABER COLLIERY.

Section of "No. 2 Rhondda Seam."

Strong Shale Top.

	Ft.	in.	
Coal	0	3	7ft. 6in.
Rubbish	0	3	
Top Coal	1	3	
Rashes and Clod	2	6	
Working Coal	3	3	
Bastard Shale, with nodules of ironstone	3	0	10ft. 10in.
Coal	0	6	
Clod and Fire-clay	1	0	
Coal	1	0	
Clod	1	0	
Coal	0	10	
Clod	1	0	
Coal	1	0	
Clod	1	0	
Coal	0	6	
	18	4	

Fire-clay Bottom.

In making a few general remarks on the South Crop Measures, it may be observed that a very striking feature is the sharp angle of inclination at which they lie, being considerably in excess of what is met with in any other parts of the Coal Field; necessitating special modes of working and conveyance of the Coal from the working faces, and special appliances for that purpose.

Another important feature is the freedom from Faults of much magnitude. In confirmation of this it may be mentioned, that in the extensive areas opened out by the collieries in connection with the Tondû Iron Works, and adjoining localities, no Faults worthy of mention have been met with.

As observed at the commencement of this Paper, the remarks

have been confined to a description of the general mining features of the Bryncethin and Ogmore district. Further knowledge is much required on many points referred to, especially in respect to the Moelgilaû Fault, which at present, so far as actual proof goes, is very limited, and must be left to be decided in the future by the further development of the district. Possibly, however, the series of Papers treating on the Southern division of the Coal-field may now be said to have furnished sufficient information and data to enable the several seams and faults to be correlated and traced with some degree of certainty, and to have recorded facts and opinions of the greatest value in guiding the further development of this large and highly important Coal-bearing area.

ON

PERSONAL EXPERIENCES IN COLLIERY EXPLOSIONS, AND WITH STANDING FIRES.

By Mr. Geo. Wilkinson.

The first explosion that the Writer was in, occurred in the year 1842, when he was going round the Pit with the Head Viewer, Under Viewer, Overman, Back Overman, and Master Shifter. The first working-place that they went into was a Stall rising about 2 inches to the yard, and about 20 yards in length to the face; the road was about 4 feet high, and the collier, having finished his day's work, had gone out. The Head Viewer stooped down on his knee to try the gas with his candle before going into the face, and as he lifted it up, the Overman coming on behind disturbed the gas, causing it to come down upon the candle, and an explosion immediately occurred. The Head Viewer threw himself on the ground, hiding his face and his hands, and thus saved himself, being only slightly burnt about the ears; the Under Viewer, Overman, and Back-Overman were badly burnt on their face and hands. The Writer was either thrown down, or fell with his face towards the ground, and escaped with nothing worse than having his hair burnt outside the brim of his leather cap, and feeling a little warmed about the ears. The explosion was confined to that district alone, and only those who were with the Writer were burnt, he and the Head Viewer being saved, by having thrown themselves on the ground as described.

The next explosion that he was in was at the top of a stone Drift, rising 6 inches to the yard, which had been driven 7 feet high by 8 feet wide, up to a seam of coal 8 feet thick, and on which a Heading had been driven about 12 yards to prove the coal. The Drift and Heading were ventilated with a brattice along the roof, 4 feet from the bottom ; 1 foot was taken up by the cross timbers and the brattice boards, which left two feet of air-course. The air travelled along the top, above the brattice boards, and returned along the bottom of the Drift. The brattice was not carried on any further than the top of the Drift, so that there were twelve yards of Heading in the coal, without any brattice.

The Writer had charge of that Heading, which the men were repairing about the middle, and he went up to the top to see if there were any gas, and after going about four yards tried the place with his candle, when one of the men came on and asked him to show him that mode of testing, and whilst they were both looking the gas came down suddenly on the candle and exploded. He immediately told the man to throw himself down on the bottom beside him, which he did, and they escaped with a slight singeing of the hair only, although the fire kept blazing and going out down the top of the brattice, which fortunately caused it to pass over the other men, and they also escaped. This small quantity of gas blew the doors down for a distance of a hundred yards from where it exploded.

On another occasion, he was travelling the Airway of some Old Workings that had been stopped for several years, accompanied by the Master Wasteman and his son, and at about six hundred yards from the Engine Bank (where they left the men that were working in another seam) they came to a Stall, turned off from a Level Heading, and driven through to the next Heading; the Stall had fallen at the mouth, on to the Level Heading, about eight feet high, and the Airwaymen had made a travelling road over the top of that fall, so that they had to get up about four feet from the Level to the top of the fall, and then down the

other side; there was a good current of air going over the fall at the time and passing round the workings. The Writer had been an Overman in that seam before it was stopped, and had never seen very much gas there, and when any was met with, it was easily detected, as it always produced four to five inches of "top" on the flame of the candle. In passing over the top of that fall he sat down, and observed that there was a good current of air; but he had not been there many minutes before the gas came down on to his candle, causing a terrible explosion. This was occasioned by his having obstructed the air by sitting on the top of the fall, and thus bringing the gas down. When it fired he tried to run out through the flames, and did not throw himself down, and was consequently exposed to them for a considerable time, and was badly burnt about the face and hands, and if he had not been protected by his clothes, most probably he would have been burnt to death. That was the last time he attempted to run through the flames of an explosion, for if he had thrown himself down until the fire had passed, he would have been little the worse. The other two men who were with him were very badly burnt, and were a long time before they got about again. They had six hundred yards to go back without any light, to reach the men in the other seam. There were about four thousand cubic feet of air passing under the gas at the time; and if he had not stopped on the top of the fall, and obstructed the air, all would have gone on safely as usual; but he might remark that it was most unsafe to use a candle in a seam that produced gas, although on that occasion he had no thought of meeting with any gas.

In December 1860, they had an explosion in the "Nine Feet" seam, in the Lower Pit, at the Lower Duffryn Colliery, which it was thought at first would not have produced such serious results as it did. It was caused by two colliers smoking in the top Stall in the first Heading on the west side. There were fifteen thousand cubic feet of air per minute going into that district, which was free from gas. The day on which the explosion

happened was measuring day, and after the Writer had measured the "Four Feet" seam, he had to go into the "Nine Feet," and reached there about one o'clock. The Stall in which the two colliers were working, was about eighteen yards in length, and the airway had not been driven through, but there was a door on the Heading, and brattice had been put up into the Stall. The colliers, after getting their dinner, had taken the top off one of their Safety Lamps, so as to light their pipes, and then opened the door on the Heading to let the air go past the Stall, and carry the tobacco smoke away, for fear he should smell it in the Stall when he came in to measure. Contrary to his usual custom he went into the East district first, and was with the Overman in the first Heading on the East side, when the two colliers, in the first Heading on the West side, went back from the Heading where they had been smoking, into their Stall, with the lamp top off, and the gas that had accumulated in the Stall during the time the door on the Heading had been open, immediately exploded. The Writer at once went back to the bottom of the Stone Drift, and there met a haulier with his clothes on fire, he being the first man that had come out from the explosion, and on reaching the bottom of the cross Heading, found that both ends of the air-bridge had been blown up, and that the fresh air was going back into the return airway, without going up the Heading; he therefore immediately set to work with the Overman, to prevent the air escaping, as they could not go up the Heading without carrying the air as far as possible with them, and this they succeeded in doing, by filling up the vacancies in the air-crossing with canvas, to make it as airtight as possible; whilst they were so engaged, the men were coming down the Heading and going out, but just before they had finished, a collier came and told them that the brattice at the top of the Heading was on fire, and that there was no water to put it out with, and anxiously inquired what should be done, as they could not get into the back Heading to get the men out. He told them to return immediately and throw up the small Coal dust of the road, with shovels,

on the brattice that was burning. And when he shortly after reached the top of the Heading, he found the fire of the burning brattice had been extinguished by the men in the manner he had directed them. The two colliers that had fired the gas passed as he was going up the Heading, and the one that had taken his lamp top off in the Stall was very badly burnt, and only lived until he got to the top of the Pit. Twelve men altogether lost their lives on that occasion, by the carelessness of those two colliers smoking.

This, however, was but the beginning of a very serious ordeal for the Writer, for although he went round those workings eight or ten times, and once with two of the Government Inspectors, and examined every place most carefully, and found no gas, yet four days afterwards a fire was discovered in the rubbish, which was about 8 feet thick, in the gob of one of the double Stalls, occasioned by a "Blower" that had been set on fire by the previous explosion, and which had been smouldering and burning in the rubbish. They consequently determined to close up the district, but to effect that was a very difficult undertaking.

The first thing that was done was to shut up the Heading where the Blower was on fire, and take the air from it altogether. They then commenced to build a stopping on the end of each stall road, down to the bottom, until they came to the last one of all in the Heading, in building which, however, as soon as the mason had put up the last stone, the gas exploded at the fire inside, and blew out the stopping upon the mason, but fortunately without injuring him.

When they found that plan did not succeed, they decided to adopt Mr. Gurney's method of filling the workings with Carbonic Acid Gas; and, to do this, came back 500 yards from the fire, and erected a firegrate on the Level, in which to produce the Carbonic Acid Gas, leaving a hole at the end of the fireplace to put in a 12-inch pipe, and when it had been completed, the Writer went with the Overman and Fireman to see it, and on going forward to look as far as he could into the hole, his

doing so checked the passage of the air, and caused the gas to explode again at the fire, and although the flame did not reach back as far as they were, yet the force of the explosion gave them a terrible shaking, so much so that the fireman left and would not go down again.

That plan having failed, it was resolved to bring back the firegrate another five hundred yards into the top of the Stone Drift, going from the "Four Feet" to the "Nine Feet" seams, and two lengths of brick arch were turned in the Drift for that purpose, and space left for a twelve-inch pipe at the end of it, through which to pass the Carbonic Acid Gas. The fire was then lighted, and the Air Pit closed from the seam up to about one-third, and the fire was maintained for three days, during which time nothing but Carbonic Acid Gas went into the seam. The top of the Air Pit was closed so that no fresh air could get in, and the Carbonic Acid Gas, which was made by burning Coke and Limestone on the firegrate, was allowed to flow through the pipe into the workings, which were then stopped up, and left so for six weeks. The workings were afterwards opened, and every precaution was taken to avoid accident in doing so. There were two furnaces in the Upcast Shaft, and one of them had been out for six hours and the other for three, before any attempt was made to open out the Upcast Air Pit of the shut-up seam. A very large waterfall was prepared from a brook on the top of the pit, and also the water of a fourteen-inch pump arranged that it could be turned into the Downcast Pit, so that before commencing to open out the workings (after the furnaces had been extinguished) there were 50,000 cubic feet of air per minute going down the Downcast. No one was allowed in the Pit, except the men especially employed for the purpose, comprising the Overmen and Firemen. There must have been acres of gas to clear out, so a man was fixed on the top of the Upcast Pit to keep away all open lights, and put out the fire under the boilers, and also in the cottages that were close by. Upon going down the Pit, the first thing that was done was to

see that the furnaces were quite cold, and all the fire out, so as to be perfectly satisfied that all was right. Operations were then commenced by taking the top off the Airpit to the "Nine Feet" seam, to let out the gas into the Heading which went into the Upcast Pit. There were 20,000 cubic feet of air per minute, coming up to meet that gas, but it came out so strong that the men had to fall back, as it quite overpowered that volume of fresh air and they had to leave the Heading and come back to the bottom of the Downcast and remain there in a cabin for about an hour, until the gas cleared off somewhat. Whilst the Writer and the others were thus waiting in the cabin, with the door closed, a most violent explosion took place with a thundering sound, such as they had never heard before, and although, fortunately sheltered in the cabin, they were no worse, the flames came out of the Upcast Pit 100 feet above the top of the Pit, and blew the top of the Pit all to pieces, and also out of the top of the Downcast Pit, against the waterfall, and 50,000 cubic feet of fresh air then going down, and so violent was the explosion that it shook all the houses near the top of the Pit. They stopped in the cabin until the air took its proper course again, before they came out, and as they all thought that the gas had been fired in the "Nine Feet" seam, they went out to see what had taken place, and where it had fired, when they met two men who had come down from the top of the Pit, thinking that they were all lost; and who begged them to come up at once, to assure those on the surface that they were alive, as their families lived near the top of the Pit. The Writer, however, wanted to ascertain if the explosion had occurred in the "Nine Feet" seam, and said he would be able to tell by the appearance at the top of the Air Pit, but most of the men said they would return to the surface; some, however, said that they would accompany him to the top of the "Nine Feet" Air Pit, so six of his men left, and were in the cage going up the Pit, whilst the Overman and one of the Firemen went back to the cabin to

get his victuals box, the Writer agreeing to wait for them at the bottom of the Pit. They had not been gone five minutes when all at once the air stopped, and knowing by that, that the gas had again fired, he told those that remained to throw themselves flat down on the ground, and what then took place they hardly knew, for pieces of coal and brick, accompanied by volumes of dust and fire, passed over them, but he told them to be still, until the air had again returned to its proper course. The only air they had to breathe was inhaled through their clothes which they drew over their faces, and if the fresh air had not returned in five minutes, he was sure they would all have perished, for it was like being in a red-hot oven, although only about 20 yards from the bottom of the Downcast. The six men that were on the cage fortunately escaped uninjured, and it was again sent down at once, hoping that some of them might get to the bottom of the Pit, but no one would venture down again from the surface. On the return of the fresh air they fortunately reached the Pit just as the cage got to the bottom, and were drawn to the surface after nearly losing consciousness. The Overman and Fireman that left them to go back to the cabin were both lost, the Overman being killed by the force of the explosion, and the Fireman being so badly burnt that he only lived a few days. If the Overman and Fireman had been with them they would both probably have been saved, but not having been in an explosion before, they did not know the value of throwing themselves down on the ground immediately. Now, although so serious an explosion took place, Mr. Gurney's mode of putting out fire by Carbonic Acid Gas was successful in that case; for when the seam was examined again, they found that the fire had been completely extinguished, and the place quite cold. In constructing a furnace for such a purpose the place should first be excavated 7 feet high by 8 feet wide, and then a 6-feet arch be built in the centre of the heading of 9-inch brickwork, and 9 feet long, leaving 1 foot of clear space on

each side, and 3 inches on the top, to avoid setting fire to the top or sides; then a 'gauging,' or stopping should be placed at the end of the arch, leaving a hole for a 12-inch pipe, 6 feet long, to pass through, and three bearing bars be fixed 2 feet from the bottom, on which should be laid two lengths of common firebars; then, by building up side walls of 9-inch brickwork, there would be a fire-grate 4½ feet wide inside of the arch. The fire should be lighted with coals until a good heat had been obtained, when it should afterwards be maintained with nothing but coke and limestone, and the gases from the fire allowed to pass through the pipe, in the stopping, into the workings beyond. That was a very successful way of putting out a fire underground, where there was the power of contracting the outlet, or return from the fire. In the case referred to there was an Air Pit from the "Four Feet" to the "Nine Feet" Seam, so that they had the control of the return air from the fire at the top of the Air Pit. Now, it was probable that they would ask how the gas exploded after the workings had been filled with Carbonic Acid Gas as described? It would be remembered that the furnaces had been out, one for six hours and the other three, and the Writer had himself examined them before they commenced to reopen the workings, and found everything cold, and apparently safe. One of the Furnaces was 50 feet from the Pit bottom, in the "Four Feet" Seam, and, as they were winding coals through that Pit, masonwork had been built up, at the end of the Furnace drift, for about 8 feet high, to conduct the smoke and flames into the pit, above the Hitchers. The wall on the pit-side has been built straight up, but on the furnace side there were steps, or slopes, so as to divert the flames and smoke upwards. On these steps a quantity of dust, or soot, from the furnace, had lodged, which was not observed or thought of when the Furnaces were put out and examined. No doubt that dust had kindled in the draught and fired the gas, as no one was in the Pits but the men with him when the furnaces were examined, and no thought was given to that dust being hot; he did not think the dust at the bottom of the furnace

did any harm, but the hot dust on those steps must have ignited the gas as it passed over. No doubt the steps should have been examined and water thrown upon them to cool down the soot, or grey dust, in which, however, it was never imagined that any fire was left after the Furnace had been out so many hours.

On one occasion, a shot was fired on a Saturday in the long wall workings, and set fire to a blower of gas about thirty yards back from the face of the Coal, but as this was in the gob, it was not discovered until Sunday morning, when the district was found to be full of smoke, and the small coal and rubbish of the gob on fire. The Writer was at once sent for, and proceeding in, had arrived about forty yards from the place, when a stone fell from a hole in the top and brought the gas down to the blower that was burning, causing an explosion from which he and the Night Overman escaped with a very slight burning, by throwing themselves on the ground immediately. The hole in the top, where the stone had fallen from, was about ten feet high, and every now and then it filled with gas and came down on to the lighted blower, causing occasional explosions, the flame spreading over a space of some fifty yards. Their men were very much frightened at that, until they were persuaded that if they would use the precaution of immediately falling down, they would be little or none the worse. They then got a fire-engine down the Pit, to a place about fifty yards back from the fire, and kept throwing the water from the hose on to the fire, and the steam thus caused diluted the gas, and eventually the water and steam put out the fire. He thought that was the best way of putting out a "blower" if it had burnt many hours, for the steam soon overpowered the gas and put the fire out.

The first thing to be attempted when a blower had ignited, was to endeavour to beat it out with pieces of canvas, or coats and jackets, which being softer would go closer to the hole, and put out the blower much sooner. Failing that, some of the following methods should be adopted:—

He once had a very strong blower in the sump at the bottom

of the Pit, which they could not in any way put out until they fixed a hose to play upon it, attached to the pump column, which was nearly three hundred yards in length, and the force of water thus brought to bear on the "blower" soon quenched the fierceness of the flames, so that it could be put out by means of canvas. Another very simple way, when the "blower" could be reached in time, was to charge a gun with powder and shoot it directly at the "blower:" that had never failed; or a hole might be bored in the bottom, in such a direction that it should not heave up the ground, and when charged with powder and fired, the concussion would put the "blower" out.

From the preceding remarks it is to be remembered that, if anyone is in a Pit at the time of an explosion, the best means of saving himself is to fall down to the ground *at once*, and after it had passed over to get up as soon as possible and go to the fresh air. He had been in five Explosions, in which he had been saved by throwing himself down, and, with the exception of a little skin burnt off the face and hands, had not been injured, whilst others who were with him were badly burnt because they did not fall down at once. If it was found that the air stopped suddenly, which was the first warning of an explosion, the safest plan was to fall down at once, for fear that the violence of the explosion might be fatal; but after it had passed, it was better to get up and make for the fresh air as speedily as possible.

STANDING FIRES.

Standing fires in Pits were very difficult to contend with: the first one that the Writer had to do with was in a long wall working, where a "blower" took fire in the corner of a Stall from a shot used in blasting the coal, and he succeeded in putting it out by building a wall of masonwork from the face to the fast side, so as to stop all the air from getting to it; but that happened in a favourable situation, for the coal was all solid on one side and also along the face; if there had been an airway on the other side it would have been much more difficult to stop the air; and,

in general, very much depended upon the situation and circumstances under which the fire occurred.

The next fire that he had to contend with was a much larger one. There were two boilers placed at the bottom of a Downcast Pit, and an arched Heading three hundred yards in length formed the return flue from those boilers to the Upcast Pit. The arch of that Heading had cracked and the hot soot and dust had passed through the crack and set fire to the coal and shale with which the arch had been backed. The Heading was through 'old work,' and, from the fire getting into the old Stall openings, it soon spread along the whole three hundred yards, all the way to the pit. As he could not stop the access of fresh air to the fire, he conveyed water through a two-inch pipe from the surface to the Heading, which gave them a pressure of about two hundred pounds to the square inch, affording a very powerful jet, which enabled them, by working night and day, to succeed in extinguishing the fire in the Heading as far as the Upcast Pit. They then had to put out the fire in the old goaf on each side of the Heading, and first tried the effect of conducting the exhaust steam from the underground engine into the goaf, with the hope that the steam would put the fire out; but, after a trial of some six months, they abandoned that plan, because they could not stop the fresh air going into the old goaf, as well as the steam. They then endeavoured to work into the old goaf; but after doing so for some yards he found that it would be better for them to open a road around the old workings, and let the fire burn through to the road so made. A roadway was accordingly opened around the fire, which extended over many acres, and as often as it burnt through into the road, by working at it day and night, and using the waterpipe and hose, they succeeded in keeping the fire back. The "Two Feet Nine" seam of coal at this place was only twenty-one feet above the "Four Feet," and they decided to work the coal in that seam over the area which was on fire in the "Four Feet" seam, and drive dip Headings and fill them with water so that it might

percolate down on to the fire in the "Four Feet." That plan was successful; for the water thus filled into the dip Headings, percolated through to the "Four Feet," and eventually put out the fire; but it took them years of patient labour, and cost a large sum. Many persons said they would be compelled to drown out the two Pits, and no doubt that would have been the surest way of extinguishing the fire; but, taking the loss arising from such a stoppage of the Pits, and everything else, into consideration, he thought it would have cost them £20,000 to have pumped out the water, and place the Pits at work again. In any case, however, fires of that description were very difficult to contend with, and dangerous to those who had to conduct the operations.

The Writer had a very similar fire in another Pit that he had charge of. When the Pit was first opened out, an Engine was placed underground, and also two Boilers, with the flues carried into a masonry arch 6 feet wide and 6 feet high for about 60 feet in length from the Boilers, and from thence the heated air and gases from the Boiler fires had to go a further distance of 150 yards through some old workings to the Upcast Pit. The old stalls had been filled up with rubbish, and it was thought that, as the Upcast was so near, the heated gases would go straight to the Pit, and not into the old workings. About eight years afterwards, however, when he took charge of the Pit, he found that the old workings were on fire. The first step he took was to bring steam-pipes down the Pit from the Boilers on the surface, to supply the underground engine, and thus do away with the underground Boilers. He then shut off all access of fresh air to the fire, and at the same time brought two water-pipes, $1\frac{1}{2}$ inches and 2 inches in diameter, down the Pit, which gave them powerful jets, with a pressure of about 70 lbs. on the square inch, to play on the fire; and by working day and night, and throwing the water continually before them on to the fire, they were enabled to make a roadway around it, and confine it to that area. Afterwards they drove into the "Two Feet Nine" seam,

and opened out over the fire, filling the places with water, so that it might percolate through the broken ground down to the fire in the "Four Feet" seam, which, as before, they found to be the most effectual way of extinguishing it, although it was not until after some years of anxious labour, that that was finally accomplished.

When Boilers were placed underground it was very necessary to put them as close as possible to the Upcast Pit, or otherwise to bring the steam from the surface down the Pit. In one case, although the return flue from the Boilers was arched for three hundred yards right up to the Upcast Pit, the arch split and cracked, and the heated gases worked through and set fire to the place, so that he had to bring steam from the Boilers on the surface, down the Downcast Pit for a distance of three hundred yards, and to take the exhaust up to the top of the same Pit again. To effect that, a 6-inch pipe was put in to convey the steam down, and an 8-inch pipe for carrying the exhaust steam to the surface. The pipes were all felted, and the only bad effect experienced was from the hot water from the condensed steam that escaped at the bottom of the Pit heating the air very much before it went into the workings.

PROCEEDINGS.

17th November 1876.

The Ordinary General Meeting of the Institute was held at the King's Head Hotel, Newport, on Friday, the 17th November 1876;

Mr. RICHARD LAYBOURNE, M. Inst. C.E., Vice-President, in the chair.

The Minutes of the last General Meeting were read and confirmed.

ELECTION OF NEW MEMBERS.

The Chairman announced that the Ballot Lists had been opened, and declared the following gentlemen to have been duly elected as Members of the Institute, viz.:—

Members.

Mr. William Moor, Mechanical Engineer, Lanely Colliery, Llantrissant.

„ Richard Cowper, Associate Royal School of Mines, Fellow of the Chemical Society, Tredegar Iron Works.

„ Eustace Robert Williams, Surveyor, South Wales Colliery, Cwmtylery.

„ William Walters, Colliery Manager, Baglan Colliery, Briton Ferry.

„ Morgan Bransby Williams, M. Inst. C.E., Uplands, Swansea.

„ James Bell, Civil and Mining Engineer, 63 Conway Road, Cardiff.

„ John Thomas, Colliery Manager, Resolven.

Graduates.

Mr. Theodore Vachell, Mining Pupil, Cardiff.
„ Thomas Jones, Colliery Manager's Assistant, South Wales Colliery, Cwmtylery.
„ Frank Lester Sadler, Student of Mining Engineering, Maesteg.
„ Samuel Henry Stockwood, Student of Mining Engineering, Maesteg.
„ Peter Roe Bedlington, Pupil in Mining and Mechanical Engineering, Aberdare.

ADMISSION OF NEW MEMBERS.

The following gentlemen, elected at previous meetings, were then formally admitted to the Institute by the CHAIRMAN, and signed the Roll Book, viz. :—

Mr. Geo. John Gee, Pontypool.
„ Thomas Harrison, Pontypridd.
„ Arthur Lawrence, Cardiff.
„ Henry Jones, Tredegar.
„ Edwd. Thos. Richards, Merthyr Tydfil.
„ Herbert Harry Young, Glyn Corrwg.
„ Wm. Gascoyne Dalziel, Aberdare.
„ Geo. James Findlay, Tredegar.

RETIRING OFFICE-BEARERS, SESSION 1875–76.

The CHAIRMAN declared the list of Office-Bearers retiring by rotation for the Session 1875–6 to be as follows, viz. :—

Vice-Presidents.

Mr. Thomas Joseph.
„ George Wilkinson.

Members of Council.

Mr. George Brown.
„ H. V. Trump.
„ Bedlington Kirkhouse.
„ James Barrow.
„ James Colquhoun, F.G.S.
„ David Davis.

Secretary.

Mr. Hort. Huxham, F.G.S., M. Inst. C.E.

NOMINATION OF OFFICE-BEARERS, SESSION 1876–77.

The following gentlemen were then duly nominated as Office-Bearers for the Session 1876–77, to succeed those retiring by rotation, viz. :—

Vice-Presidents.

Mr. Thomas Joseph.
„ George Wilkinson.

Members of Council.

Mr. George Brown.
„ H. V. Trump.
„ James Barrow.
„ James Colquhoun, F.G.S.
„ Wm. G. M'Murtrie, F.G.S.
„ A. J. Stevens.

Secretary.

Mr. Hort. Huxham, F.G.S., M. Inst. C.E.

The discussion of Papers read at previous meetings was then proceeded with.

ADJOURNED DISCUSSION ON "BLOWERS AND OUTBURSTS OF GAS."

The CHAIRMAN said the first Paper, of which they would resume the discussion, was that by Mr. Wilkinson on "Blowers and Outbursts of Gas," which was a subject of much interest to those having the conduct of collieries giving off much gas. He would invite Mr. Wilkinson to resume the discussion.

Mr. WILKINSON said that his Paper was chiefly a record of his personal experiences in dealing with fiery collieries, and there were possibly some statements in it which might appear, at first sight, to be somewhat contrary to the usual experiences of a colliery manager. For instance, he had stated that at three of the collieries under his charge, which were ventilated by furnaces, there was always an increased amount of ventilation, or a larger volume of air passing through the workings, when the barometer was *low*, than when it was high. This, no doubt, would be contrary to the experience of most of the Members present, but would be explained when it was remembered he had also stated that at those three collieries he had repeatedly seen the return air passing over the furnaces so heavily charged with explosive gas, that the ordinary short flames of the furnace were lengthened to the extent of 30 to 40 feet and more by the gas burning as it passed over the fire. The natural result of a heavy fall in the barometer was to liberate large quantities of explosive gas in the old goaves, and it was only on occasions of a *low* barometer that the return air became so heavily charged with gas as to produce the phenomena he had referred to, which, during his 40 years' experience, he had only seen at those three furnaces, and only where steam coal, giving out a pure white flame, was used on the furnace. On occasions, therefore, of a *low* barometer, the flames of the furnace were increased to such a degree that its heating power was then at its maximum, and the temperature of the air in the upcast shaft was soon raised much above its ordinary condition; so that its ventilating power, and the quantity of air passing through the colliery, was considerably augmented. Another point that required a good deal

of investigation, and on which he had been unable to satisfy himself, was the condition under which carburetted hydrogen existed in the strata. They had the condition of the sudden blower or outburst of gas, and also that of a continued saturation and exudation, depending on the varying pressure of the atmosphere. In large goaves, of many acres in extent, in the collieries referred to in his Paper, he had found that with a low barometer, or when the atmospheric pressure was removed, say, to the extent of one inch of mercury, or some 70 lbs. on the square foot, the gas invariably came pouring out in large volumes, so as oftentimes to completely fill the return airways; but immediately the barometer began to rise, the outflow of gas was checked; and on recovering the inch that it had fallen, or, in other words, when the atmosphere again exerted an increased pressure of 70 lbs. per square foot, the outflow not only ceased, but the gas entirely disappeared, and was pressed back again into the pores and crevices of the strata. The questions naturally arose, Where did the gas come from, to appear in such vast quantities, as at times it often did with a low barometer? and also, Where did it go to, on the pressure being restored? He remembered the case of a sinking pit under his charge, where they had sunk down some 13 yards in a sandstone rock, without anything noticeable except that there were cracks in the rock, out of which explosive gas issued in such considerable volume, when the barometer was low, as to stop their working, and this usually occurred with a south or south-west wind; but when the wind changed towards the north, and the barometer rose again, the gas not only entirely disappeared, but an in-current of air was established, so that it would draw the flame of a candle into the crevices in the rock. Another example of the elastic power of the gas, if it might be so termed, was in a colliery where a considerable area of coal had been worked out, leaving a goaf of many acres in extent, and the only approach that had existed was by the intake and return drifts, which, having been driven through a swamp, had filled up with water for a distance of some 300 yards, completely sealing

up the old workings beyond. He had thought that that water would have been an effectual barrier to prevent his having any trouble with the gas that might be made in the old workings, but he found that whenever the barometer fell, indicating a less atmospheric pressure, the water rose up, at times, as much as 30 feet along the inclined plane, and when the barometer rose again, retired to its previous level; so that every rise or fall of the barometer was indicated by the rise and fall in the level of the surface of that water, due, as he considered, to the power of the gas, which probably filled the old workings beyond. He would have much pleasure in replying, so far as he could, to any questions that Members might wish to ask.

Mr. R. Bedlington considered that the variations of the thermometer produced an important effect. Let them assume a case in which the barometer stood at 30 inches, and the thermometer at 60 degrees, and that the former fell to, say, 29 inches, whilst at the same time the latter only registered, say, 35 degrees; it was evident that whilst the furnace kept the column of air in the upcast at its ordinary temperature, that of the downcast column would have been considerably reduced, thus giving a great increase of power in the ventilation and an increased quantity of air circulating through the workings, even with a low barometer. No doubt the disappearance of the large amount of gas which was frequently observed to flow out of old workings when the barometer was low, was due to the increased atmospheric pressure when the barometer rose, forcing it back again into the fissures and pores of the strata from which it had exuded.

Mr. Wilkinson said that, as a rule, he had observed that the temperature (except, perhaps, in the height of summer) usually rose with a falling barometer, and fell when it rose, so that there would be, under ordinary circumstances, a larger amount of ventilation with a high barometer than when it was low. The circumstances, however, at the three collieries to which he had referred, where the reverse effect was invariably produced, were,

of course, very exceptional, and purely resulting from the increased heat of the furnace consequent on the burning of the gas, which came over it with the return air.

A vote of thanks was unanimously accorded to Mr. Wilkinson for his interesting Paper, and the discussion was brought to a close.

ADJOURNED DISCUSSION ON "THE PENCOED, MYNYDD-Y-GAER, AND GILFACH-GOCH MINERAL DISTRICTS."

The CHAIRMAN said they would now proceed with the discussion of Mr. Henry K. Jordan's Paper on "The Pencoed, Mynydd-y-gaer, and Gilfach-goch Mineral Districts," which formed one of a series of Papers that had been brought before the Institute by different members, and he hoped that by and by they would be able to compare and identify the different seams of the South Wales Coal Field, which were now known by such various names throughout the district. He invited Mr. Jordan to resume the discussion.

Mr. HENRY K. JORDAN said that before the further discussion of his Paper commenced, he thought it might be convenient that he should reply to the observations made at the last meeting.

His reason for differing in opinion with Mr. David Thomas, as to the position of the Anticlinal near Cwm-Afon, was that the strata had the same direction of dip on each side of the line laid down by that gentleman in his plan, as the Anticlinal line; which, of course, was inconsistent with the existence of an Anticlinal. He considered the true position to be nearly three-quarters of a mile further south, where the strata might be seen rolling over and dipping in opposite directions.

In reply to Mr. Begg, he stated that he had no desire to question the accuracy of the pit measurements given by that gentleman, of the distances between "No. 2" and "No. 3 Rhondda" seams, at several localities in the Rhondda Valley, none of which amounted to 80 yards, but in the district embraced by his Paper the thickness was greater. At Gilfach-goch it was about 90 yards, and in the Ogmore it was—according to

the levellings of Mr. George Birbeck—no less than 125 yards, and the mean of three measurements in the district under notice was 97 yards, so that he considered he was within the mark in taking it as 90.

He would, however, admit that it would have been better had he used the words "average distance" instead of "normal distance," owing to the great variation of the distance between those seams.

Near Pontypridd it was less than 70 yards, increasing, as stated, to 125 yards in the Ogmore Valley, and if, as was generally considered, the "Wernddu" seam was the equivalent of the "No. 2 Rhondda," then the thickness had increased to 196 yards at Cwm-Afon, and to 220 yards at Baglan.

That was another remarkable instance of the *westward thickening* to which he had drawn attention in his Paper (Vol. IX., No. 5, p. 265).

It might, perhaps, be interesting to the Institute if another instance were given:—

At Llwyn-y-pia Colliery the distance from the "No. 3 Rhondda" seam to the "Abergorchi" seam was 96 yards, and in one mile of westing it has increased to 121 yards, at Clydach Vale Colliery; in the Ogmore the distance was 135 yards, and at Maesteg 222.

With regard to the two Faults, as to the existence of which Mr. Begg expressed a doubt, he might state that the 85-yard Fault was actually proved in Pen-y-graig Colliery before his Paper was written, and since its publication the Fault had also been struck at Gilfach-goch Colliery. The other Fault was described as a "Probable Fault," but he had no doubt that it existed, for the reasons stated in his Paper.

In reference to Mr. Begg's desire that he should correlate the seams of coal at Llwyn-y-pia with those of other districts, he stated that he had never heard any doubt expressed as to the upper seam, wrought at that colliery, being the "No. 3 Rhondda," and he believed that the steam coal seam worked at that pit

was generally considered to be the "Six-Feet" seam of the Aberdare Series.

The next point discussed by Mr. Begg was one of great importance and considerable difficulty, namely:—"Do the *Llantwit seams* exist under the Ely Valley?" That gentleman considered the seams of coal in the centre of the trough at Tylca, near Ton-yr-efail, to be beneath the Llantwits, whereas he considered them to be superior strata. He freely admitted that a great preponderance of opinion was against him, and in accord with Mr. Begg; but his reasons for considering the "Tylca," or "Tyclu," coals were not *sub-Llantwit* were:—

1. That they never have been found beneath the *Llantwits.*
2. That the workings in the "No. 3 Llantwit" seam, at Llantwit Main Colliery, are nearly 300 yards beneath the level of the "Lower Tylca" seam, and the "Llantwit" seam was still dipping north, towards the centre of the trough.
3. That if the "Tylca" seams were *sub*-Llantwit, then there must be, between the Llantwit Main Colliery and Tylca, either a reversal of the inclination by which the Llantwit coals were again raised to the surface, or a gigantic Fault, sufficient not only to raise the "No. 3 Llantwit" seam 300 yards to the surface, but also to raise it 100 yards higher than the level of the "Tylca" seam, inasmuch as there are nearly 100 yards of strata over the "Lower Tylca" seam in which the "Llantwits" cannot be found. Of such a reversal of dip, involving another Anticlinal, he had no knowledge, nor was it shown in the Ordnance Maps; neither was he aware of the existence of an upcast West Fault, the *minimum* magnitude of which, as shown, could not be less than 400 yards.

If, on the other hand, they took his interpretation of the district, namely, that the "Tylca" seams were *super*-Llantwit strata, they need not assume the dying out of those "Tylca"

seams in the Llantwit district, neither need they call into requisition a reversal of inclination, nor a Fault greater than was known to exist, and they would also have in that district the highest strata of the series in the centre of the trough, as was the case in all other areas of the Coal Field.

There were other facts and considerations which strongly supported his views, but he thought that perhaps sufficient had been stated to enable Members who took an interest in that portion of the Coal Field, to determine whether the facts he had presented justified the conclusions at which he had arrived.

Mr. David Thomas said that, with reference to the line of the Anticlinal through Cwm-Afon Valley, he thought its position was clearly demonstrated by the inclination of the strata on the north and south side of the valley, as shown in his Paper on that district. The "Wernddu" seam, which Mr. Thomas Joseph had referred to in a previous discussion, was on the top of the Bwlch hill, nearly 1,100 feet above the sea level, and the same seam was proved by a level driven upon it by the side of the Cwm-Afon Railway, at Tumble, and within a few hundred yards of the town of Aberavon. From that point eastwards the strata could be seen dipping as regularly as possible, some 8 to 9 inches in the yard, nearly to Cwm-Afon. The Anticlinal had also been distinctly proved by levels driven at Baglan, and also by levels higher up the hill, within a few hundred yards of Baglan Church. The same seam, dipping north-east, was being worked by Mr. Vivian in the Duffryn Valley, and could also be seen near Bryndu, where it went under the name of the "Rock Fawr." The line of the Anticlinal took its course from Baglan to Cwm-Afon, and twenty-five years ago he had proved it distinctly at a place called Pencastle, to the south of Cwm-Afon Works, and it could be followed to Efil, where it could be seen by the form of the ground, above and below the Anticlinal line. He had also explored it on the Varteg hill, not far from the Llynfi Iron Works, where he had proved the "Tormynydd" seam to be dipping south, and they had also worked that seam near Drysiog Colliery, dipping to the north. He thought if Mr. Jordan spent some time in closely examining the Aberavon

District, he would find that what he had taken to be the line of the Anticlinal was, in fact, only a local roll of the strata that did not extend for more than half a mile, in a south-east direction, from the town of Aberavon towards the Margam Chapel of Ease, and there ceased. This Roll had been proved by workings on the "Wernddu," or "Goitre" seam, by the Governor and Company of Copper Miners, near Upper Margam Tin Plate Works, where the seam was 4 feet thick, with a rock roof. He could not reconcile the position assigned to that portion of the Anticlinal by Mr. Jordan with the facts that he had stated, nor was he disposed to give up his conclusions unless he had much more convincing evidence.

Mr. Hugh Begg was sorry he had arrived too late to hear the first part of Mr. Jordan's remarks, but from what he had heard he saw no reason for altering his opinion that the "Tydu" veins underlay the "Llantwit" seams; for he believed the former lay on the top of the Pennant Rock, between the "No. 1 Rhondda" and the "Llantwit" seams. He thought the "Tydu" vein, and the vein at Caradog Vale Colliery and at Bettws were identical, and all underlay the "Llantwit" seams. His first experience in South Wales was boring from the "Tydu" seam, under the supposition that the "Llantwit" seams lay below; but nothing was found within the 110 yards which were proved. Mr. Birbeck's section showed no vein of coal for a distance of 240 yards below the "Bettws Four-Feet," which was in accordance with an exposed section of the strata all the way from the "Tydu" vein to the "No. 1 Rhondda," at Ton-yr-efail, where there was no appearance of coal. There was an idea that the "Bettws Nine-Feet" existed about 80 yards under the "Bettws Four-Feet"; but no one had ever been able to prove that hypothesis, although several boreholes have been put down to considerable depths in that neighbourhood. He thought that the "Bettws Four-Feet" and the "Tylcha" and the "Tydu" veins were identical, lying on the top of the great Pennant Rock.

Mr. Colquhoun thought that they might go on discussing those points for a considerable time without coming to any

definite agreement, because in many parts there were not sufficient indisputable data furnished to enable them to do so. With regard to the precise position of the Anticlinal, he thought it would be difficult in many places to say exactly where it passed, as he had known as much as 400 yards in width of the strata at the top of the Anticlinal to lie so flat, that it was impossible to draw its precise line. He thought that the better course would be for a Committee to be appointed to carefully examine the several Papers on those subjects, and fairly investigate the whole matter, and endeavour to arrive at some definite conclusions.

Mr. Thos. Forster Brown thought the suggestion that Mr. Colquhoun had made was worthy of their best consideration, for he quite agreed with him that a Committee could deal very much better with the question than was possible in open discussion. The duty of such a Committee would be to draw up a careful synopsis of the various seams, and the relative position and identity of each vein met with, in Monmouthshire and Glamorganshire, introducing the latest knowledge bearing on the subject from each district, and tabulating the same in a Report to the Institute. He would advocate the appointment of a Committee for that purpose.

Mr. C. H. James asked whether Mr. Jordan could explain how he arrived at the measurement of 485 yards, which he had given as the distance between the "Llantwit" vein and the "No. 2 Rhondda."

Mr. Hugh Begg said that at Ton-yr-efail, where the "Tydu" seam cropped out, there was a distinct section to be obtained from that vein for the greater part of the way to the Anticlinal, and the outcropping of the "No. 1," "No. 2," and "No. 3 Rhondda," and the "Hafod" and "Abergorci" veins. The "Tydu" seam was there 4 feet thick, and he had measured the ground below it, and taken the angle of the dip of the strata, down to "No. 1 Rhondda," some sixteen years ago, and found that the vertical distance from the "Tydu" to the "No. 1 Rhondda" was 550 yards, of which nearly the whole was Pennant Rock.

Mr. GEORGE BIRBECK thought it would be advisable that the cross sections, which had been taken from the south crop of the measures northwards, in the several Papers before the Institute, should be continued to the north outcrop, as the additional information that would be thus afforded would be of much service to any Committee in assisting them to arrive at definite conclusions.

Mr. DAVID THOMAS quite concurred in the suggestion that a Committee should be appointed to report on the matter.

Mr. JAMES BARROW said he had three measurements from the "Llantwit" to the "No. 2 Rhondda" veins, which gave 500, 520, and 525 yards respectively. He thought there was no better mode of solving the various questions that naturally arose on such an important inquiry, and he supported the appointment of a Committee.

Mr. R. BEDLINGTON said that most of the Members would agree as to the identity of almost all the seams from the east outcrop, in Monmouthshire, westward, into the Rhondda Valley, but as soon as they went further westward and southwards, into the Neath, Ogmore, and Llynfi valleys, a great difference of opinion existed as to the identification of the various seams; and he should be glad to support the appointment of a Committee to clear up those doubts.

The CHAIRMAN said that, although no formal resolution was passed, it might be taken that it was the wish of the Members that such a Committee should be appointed by the Council.

Mr. HENRY K. JORDAN, in reply to Mr. James, said that the way by which he had obtained the distance from the "No. 3 Llantwit" to the "No. 2 Rhondda" seam in the Llantrissant District, was by measuring the inclinations of the strata from the mouth of the Llantwit main slope, to the "Rock Fawr" seam, which gave him a perpendicular thickness of 575 yards. He considered the latter seam to be identical with the "No. 3 Rhondda," for reasons stated in his Paper, and in that opinion he was supported by Mr. George Birbeck, Mr. R. Bedlington, and other gentlemen. From that measurement of 575 yards he had deducted 90 yards (the average distance between the "No. 2"

and "No. 3 Rhondda" seams), so as to get the distance to the "No. 2 Rhondda," which as yet had not been proved in the Llantrissant District, and thus he had arrived at the 485 yards as stated.

ON "THE DRAINAGE OF THE TAFF VALE DISTRICT."

The CHAIRMAN said that the next Paper for discussion was that of Mr. Bassett's on "The Drainage of the Taff Vale District," but as Mr. Bassett was unable to be present that day, it would perhaps be advisable to postpone the discussion until the next meeting.

The discussion was accordingly postponed to the next meeting.

DISCUSSION ON "THE BRYNCETHIN AND OGMORE VALLEY MINERAL DISTRICT."

The CHAIRMAN said that the next Paper for discussion was that of Mr. Birbeck's, on the "Bryncethin and Ogmore Valley Mineral District." Perhaps Mr. Jordan would open the discussion.

Mr. HENRY K. JORDAN said that he had not intended to open the discussion upon Mr. Birbeck's Paper, but as the President had invited him to do so, he would make a few observations upon it.

He noticed that the Author had omitted from his sections the "Big, or Nine-Feet Bettws" seam, and considered that he had exercised a wise discretion in so doing, on account of the great uncertainty which existed in regard to it. Up to two or three years ago, the "Nine-Feet" had always been supposed to be either a seam lying beneath the "Little Bettws," or as being the "Little Bettws" seam locally thickened. He doubted the former, because it never had been found beneath the "Little Bettws," although many attempts had been made to find it, nor could it be found outside the southern outcrop of the "Little Bettws" seam; neither did he agree with the latter opinion, for the reasons that although the "Big Bettws" was found close to the northern out-

crop of the "Little Bettws" yet it differed entirely in section, structure, and quality; besides which, its ash was of a different colour, which he regarded as strong evidence of its being a distinct seam.

The balance of evidence, he thought, went to support the suggestion he threw out at a meeting some three years ago, that the "Big Bettws" was a superior seam to the "Little Bettws," and only existed in a narrow strip, faulted down by two trough Faults.

He should be glad if Mr. Birbeck could give any further information respecting the "Pentwyn" seam, in regard to which a great deal of interest attached.

There was one point which afforded him considerable satisfaction, namely, that Mr. Birbeck had made an independent measurement of the magnitude of the Moelgilau Fault, and the result was a close agreement with the measurements he had given in his own Paper. He noticed also that Mr. Birbeck concurred in the opinion that the "Rock Fawr" seam was the equivalent of the "No. 3 Rhondda," and it was satisfactory to find that there was now a general concurrence of opinion to that effect.

With regard to the Nantymoel Fault, which he had no doubt was a continuation of the Glyncorrwg Fault, he considered that Mr. Birbeck had under-estimated its magnitude, and that it would prove to be at Nantymoel a dislocation of 180 to 200 yards.

He was of opinion that the Garw Fault diminished as it went south, because the strata on its west side, at Pwll Carn, had a rise toward the Anticlinal of several inches to the yard, whilst on the other side of the Fault the strata were nearly horizontal.

He congratulated the Author upon the line of section which he selected, and considered his Paper to be well worthy of the Institute, and by no means an unimportant contribution to the Geology of the Coal Field.

Mr. George Birbeck said that the "Bettws Nine-Feet" seam had been supposed to exist about 90 yards under the "Bettws Four-Feet," until comparatively lately. He had, however, put

down two boreholes, one 202 yards, and the other 201 yards, both holes proving very nearly the same section of ground, but in neither case was the "Nine-Feet" seam met with. At another place he had put down a borehole where he had expected the "Pentwyn" seam to exist, but had failed to find the seam at that point. The "Pentwyu" vein, where intersected in the Level, was about 3 feet 6 inches in thickness, which increased in about 150 yards to 4 feet, and then it was cut off by the junction of two Faults, beyond which the seam was not proved. In respect to the Moelgilau Fault, he took a section of the south crop from the lowest seam of coal, taking the inclination of the strata there, and also at Brynminin and Bryn-Wrach, where the rocks are exposed in a quarry; from which measurements he arrived at the conclusion shown on his section. (*See* Plate 2, Vol. X.) The Nantymoel Fault was proved, in the face of the Level, as a downthrow southwest, and they followed it down some thirty yards, but did not obtain satisfactory evidence of the full extent of the Fault. They had lately met with a Fault in the Wyndham Pit, but were uncertain whether it was the same; so that definite information was wanting as to the real extent and direction of that Fault. It was evident that a Fault traversed the Garw Valley, because they found the "No. 2 Rhondda" on a higher position on the south side of the Fault, but as to its extent they had no definite information. Probably the workings extending from Nanthir would afford the means of proving that more definitely.

Mr. James Barrow said that in respect to the widely spread supposition of the "Bettws Nine-Feet" underlying the "Bettws Four-Feet," there had recently been a pit put down at Bettws to a greater depth than had been yet sunk in that locality, and at that point the seam proved from 9 feet to 10 feet thick, of very fine coal. The boreholes which had been put down on the south side of that pit, in the deeper part of the coal field, were continued for over 200 yards, and one hole 300 yards, without meeting the coal. He was of opinion that in the district where

these boreholes were put down there were some 500 yards of barren sandstone ground from the "Bettws-Four Feet" to the next workable seam of coal.

Mr. George Birbeck said that if the seam of coal, which Mr. Barrow stated had been found in the bottom of the pit recently sank near Bettws, were the "Nine-Feet Bettws," it would show that there was a very great alteration in the stratification between that pit and the site of the boreholes that had been referred to. In the immediate locality of that pit there were two Faults—one to the westwards, the well-known Moelgilau Fault; the other, to the eastwards, a Fault that passed close to the bottom of that pit. Those two Faults ran together near the Garth Colliery, forming one Fault from there northwards. The "Bettws Four-Feet" cropped out some little distance eastwards of the pit referred to by Mr. Barrow, which lay between the two Faults; it was possible, therefore, that the coal found in that position, and called the "Bettws Nine-Feet," might be a seam higher up in the strata than the "Bettws Four-Feet," and brought down to that position by the Fault that passed close to the pit; or otherwise, to harmonise those facts with Mr. Barrow's statement that there were some 500 yards of barren sandstone, from the "Bettws Four Feet" down to the next workable seam of coal, it must be supposed that the Fault which passed close to the pit was a downthrow of very considerable extent, of which they had no evidence at all in the adjacent district. Curiously enough, the coal that was called the "Bettws Nine-Feet" had only been found North of that Fault, and had not been proved in any other spot that he was aware of.

Mr. Hugh Begg said that veins of coal sometimes altered in thickness and general character very materially in short distances. He had seen the "Tydu" vein vary in a short distance from 6 feet thick down to 20 inches, and it applied also to the "Bettws Four-Feet" vein; he had seen it wrought in two coals in the same level at Llynfi. He once went from

Tonyrefail to Bettws to see the "Nine-Feet" seam which he had been informed was at work there, but on arrival he found the pit was closed, and he never saw it. He was inclined to think that the so-called "Bettws Nine-Feet" was merely the "Bettws Four-Feet" under different conditions, between the Faults; the two seams had never been worked or proved, perpendicularly under one another, in the same ground. He thought the "Bettws Four-Feet" was the same vein, and equivalent to the "Tydu" or "Caradog Vale" seam, as each of these lay upon the top of the great Pennant Rock, and formed the lowest vein of the upper series. Supposing the "Pentwyn" vein to be purely of a local character, there would be no workable seam until the "No. 1 Rhondda" was reached, giving a belt of barren sandstone strata of some 500 to 600 yards, without any workable coal. He would like to know Mr. Birbeck's opinion of his suggestion that the "Nine-Feet" was merely the "Four-Feet" under altered conditions, for he had seen the latter as thin as 2 feet, and as thick as 6 feet within 300 yards; and if he did not agree in that view, whether the "Nine-Feet" was above, or below the "Four Feet"?

Mr. George Birbeck said that so far as the characteristics of the two coals went—in quality, thickness, character of roof, and floor—his experience led him to the conclusion that they were two distinct seams. He had personally inspected the workings in the "Nine-Feet" coal, near Capel Bach, that Mr. Begg had unfortunately been unable to see. He could not answer the question as to whether the "Nine-Feet" was above or below the "Four-Feet," as a fault ran between the two workings, and, as yet, he had not sufficient data to determine that point. Neither did he attempt to correlate either of those seams with others in the district.

Mr. Thomas Forster Brown observed that Mr. Birbeck, in his sections, had shown the ground between the seams, from the "No. 1 Rhondda" down to the "Abergorci," to be all Pennant Rock, and he would be glad to know if that was generally correct in respect to the Ogmore Valley and Llangeinor measures. In

the Garw Valley they had met with several beds of softer ground between the "No. 1" and "No. 2 Rhondda."

Mr. GEORGE BIRBECK said that "No. 1 Rhondda" cropped out at the top of the mountain, and there was some ground near the surface not definitely proved. He thought, however, with the exception of some 13 yards overlying the "No. 2 Rhondda," that it was chiefly rock, with some few beds of shale; but from the top of the Wyndham Pits the section was a record of the ground passed through in sinking.

Mr. THOMAS JONES PRICE suggested that as there were many points of great interest in Mr. Jordan's and Mr. Birbeck's Papers that had not yet been touched upon, it was, perhaps, desirable that the discussion should not be then closed, but adjourned to the next meeting.

The CHAIRMAN concurred in that course, and, accordingly, the further discussion of the two Papers was adjourned to the next meeting.

DISCUSSION ON "PERSONAL EXPERIENCES IN COLLIERY EXPLOSIONS, AND WITH STANDING FIRES."

The CHAIRMAN said that the next Paper for discussion was by Mr. Wilkinson, on "Personal Experiences in Colliery Explosions, and with Standing Fires." He thought the record of such experiences would be of considerable value, especially to the younger members of the Institute, although he hoped that few of them would have to encounter similar risks and difficulties to those that had been experienced by Mr. Wilkinson, and that the substitution of the fan for furnace ventilation would enable fiery collieries to be worked with greater safety, and less exposure to those terrible occurrences recorded in his Paper.

Mr. JAMES M'MURTRIE said that, although Mr. Wilkinson's Paper took a different line from Papers usually read before institutions of scientific character, yet it was the means of bringing before them valuable information of a practical character, which would otherwise be lost. He thought that the

younger members should especially take warning from the record of those experiences not to attempt to run so many risks as appear to have been ran by the Author and those with him. In respect to the application of Goldworthy Gurney's system of extinguishing underground fires by saturation with carbonic acid gas, he had a case within his own personal knowledge where it had been applied without successful results. About thirty years ago a colliery in Scotland took fire, which was burning to that day, and he thought would continue to do so as long as any coal remained within its reach. The seams at that colliery dipped at a considerable angle, and a pit had been sunk to the coal some distance to the deep, from the outcrop. The fire occurred near the bottom of the pit, which collapsed, preventing access to the workings, and the fire continued burning for many years before any attempt was made to extinguish it. For that purpose, the pit being inaccessible, a 9-inch diameter borehole was put down from the surface into the burning seam of coal. A steam boiler was erected near the borehole, so as to command a supply of steam at 150 lbs. pressure, and a furnace built for producing carbonic acid from coke and limestone, according to Gurney's method. The carbonic acid gas was led to the borehole, and forced down by a continuous jet of the high-pressure steam, and that operation was continued for some time, but without success, probably from the fact of the outcrop of the coal being so near that the workings were not hermetically sealed, and that a supply of fresh air found its way to the fire through the outcrop and old workings. He had had some little experience in dealing with standing fires. In Somersetshire they had some additional difficulties to contend with, for in some of the seams in the under division, the strata was so tender that linings of brushwood had to be introduced to keep back the friable ground, in the air courses and travelling ways. In one of these seams the timber and brushwood caught fire, and also some of the coal, but after considerable trouble they succeeded in putting it out (as they thought) by smothering it with fine dust.

He had, however, caused the workmen to lie down flat, with their faces to the ground, having some doubts whether the fire was completely extinguished, and was not altogether unprepared for the result of an explosion which took place soon after, followed by two or three others; but eventually they succeeded in putting out the fire completely. These latter explosions had arisen from a blower, which had become lighted in an unseen crevice in the roof, an occurrence requiring care after a fire.

Mr. WILKINSON acknowledged that he had ran too many risks, such as he would never repeat or ask anyone else to do. Fortunately the Coal Mines Inspection Act had removed many of the causes and many of the temptations which he had several years ago to battle with. He agreed with Mr. M'Murtrie that the Gurney system of extinguishing underground fires by the use of carbonic acid gas was not likely to succeed, unless the fire could be so isolated and sealed up as to be within the power of the operator to completely exclude the access of fresh air to it. He looked upon that as one of the essential conditions of its successful application. And, secondly, that the operator should be able to control the inlet of the gas and its return to the main airway or upcast pit. Subject to those conditions, he had used the Gurney process most successfully in putting out fires that would otherwise have been unapproachable, as mentioned in his Paper.

Mr. GEORGE BIRBECK had read the Paper with great interest, for it taught them many lessons. He did not think it was requisite to go very deeply into science to prevent explosions, but rather to work by the application of the experience that they had obtained at so much cost. Mr. Wilkinson acknowledged that he would not now run the risks that he had given us the record of; and that ought to be a striking warning to all—old as well as young—that if ever gas was met with in a colliery they should always be apprehensive of its being there again; and that accidents from explosions could only be prevented by strict discipline and the use of safety lamps. He remembered a case of a standing fire when he was at the Duke of Bridgwater's collieries in Lancashire, where some mischievous boys lighted a

fire in a heading, which set fire to the coal and rapidly extended before they could master it, so much so that they decided to shut it off with stoppings, which were built as closely as possible to prevent the access of air, and allowed to remain for four months; after which time they commenced to re-open the roadways, and found the coal coked for a considerable distance, and quite cool; but as they approached further, and the access of fresh air was longer continued, the dormant fire again broke out even more fiercely than before, when they again closed up the district with stoppings, increasing them to double the number they had before, and allowed the place to remain for six months. On re-opening the workings at the end of that time, however, the result was precisely similar, and in a short time the fire raged as before. They then determined to drown out the colliery, which ultimately effectually put out the fire; but it cost them some £12,000 to pump the water out again and reinstate the colliery, and occupied about eighteen months. He had a case somewhat similar to that named by Mr. M'Murtrie, in which the coal had fired from an explosion, and they attempted to put it out by using the Gurney process, and continued for many days to send down large volumes of carbonic acid gas, but with very little effect on the fire, for the workings were not far from the outcrop of the coal, and he had little doubt that the fire was fed by air which found its way through the fissures of the strata from the outcrop. In another place, three miles distance, where there had been an explosion which set the coal on fire, Mr. Gurney came to superintend the application of his process, and carbonic acid gas was sent down for over a fortnight continuously, when they felt confident that the fire had been extinguished; but on re-opening the colliery the fire was found to be still burning, and ultimately had to be put out by drowning out the workings.

He mentioned those cases to show the necessity of anyone adopting that process considering well whether he could seal up the workings so as to completely exclude the air; if he could not, there would be no chance of success. About four months ago a pair of timbers were knocked down in one of the collieries

under his charge, and when the timbermen went in to replace them, some of the roof came down, which was so hot that the men could not touch it; and on trying further up found the ground above the coal to be on fire: they immediately proceeded to isolate that portion of the workings by building up stoppings so as to exclude the air, and inserted two thermometers so as to be able to read the results. He believed that the fire was now nearly extinguished, as the place was fast cooling down. The origin of that fire was probably spontaneous combustion.

Mr. WILKINSON had every confidence in Gurney's process, where the conditions were favourable. In the case he had referred to, where the results were so successful, he had a stone heading for sealing the workings, and no air could go in but carbonic acid gas, and he had the outlet under complete control—one intake and one return only.

Mr. HENRY K. JORDAN observed that Mr. Wilkinson, after describing various *air bridges*, recommended that they should, where practicable, be driven in the solid ground; he wished to ask what thickness of strata he would on an average consider it prudent to leave between the bottom of the air bridge and the top of the heading over which it was driven.

Mr. WILKINSON said that in the Aberdare seams he would leave not less than 14 feet of solid ground, and slope the air-bridge heading some distance up on one side and down on the other, over a solid pillar of coal.

The CHAIRMAN considered the Paper that they had had under discussion was a most valuable one in its practical bearing, and he proposed that a vote of thanks be given to Mr. Wilkinson for his Paper.

A vote of thanks was unanimously accorded to Mr. Wilkinson, and the discussion adjourned to the next meeting.

Mr. Hugh Begg's Paper on "Natural and Furnace Ventilation" was taken as read, so as to be printed in the next number of the "Proceedings."

A vote of thanks to the Chairman closed the proceedings.

ON

NATURAL AND FURNACE VENTILATION.

By Mr. Hugh Begg.

Furnace ventilation may be popularly defined, in principle, as *natural ventilation accelerated.* But natural ventilation acts where a furnace cannot be applied to increase it.

It is well known in practice that ventilation is maintained where there is considerable waste going on, in levels, dip headings, and sinking pits, with only one opening; in such cases the furnace is inapplicable to accelerate the supply. How this waste is maintained is a problem that cannot be clearly solved; possibly, the vitiated air from the working faces and pit bottom, works through the fresh air, from the sources of supply, in strata or spirally.

However, extensive mining operations cannot be undertaken with one opening; but, nevertheless, this principle of natural ventilation is an invaluable one in its action in the best artificially ventilated collieries.

It is generally understood that natural ventilation is the air current that is maintained by means of two shafts or openings, or one divided into two parts, by an air-tight partition. By either means a steady supply of air will be generally maintained, which in a case yet to be referred to, amounted to 760 cubic feet per minute, for each square foot area of shaft. But the supply of air, with two shafts, or one divided into two, without some motive power, would be precarious for an extensive colliery to depend on, consequent on changes of temperature and pressure at the surface.

We have defined furnace ventilation, popularly, as natural ventilation accelerated; the general idea being that the side of the shaft imparts its heat to the air that fills it, or passes through it, and thus rarefies the air so filling, or passing through it, and creates the motive power in natural ventilation.

But we have said that a supply of air would be precarious because of changes of temperature at the surface, for it has been maintained by those who make the heat of the shaft the moving power in natural ventilation, that the two shafts become alternately the upcast; the deeper shaft being the upcast in winter, when the air at the surface is at a lower temperature than the sides of the shafts, and the downcast in summer, when the air at the surface is at a higher temperature than the sides of the pit; the agency of the sides of the shafts being the same so far as the moving power in ventilation is concerned; in winter the sides of the shaft heated the air and thus the deepest pit became the upcast; but in summer the shaft acting as a refrigerator, produced an opposite course in the air. The same result, on this hypothesis, would be produced by larger and smaller shafts; the larger shaft, with its greater heating and refrigerating area, would become the upcast and downcast, according to the variations of the surface temperature, except it was neutralised by very great disparity in depth.

With such a motive power as is here asserted, it may well be pronounced precarious to depend upon. The enunciation of the theory declares a time, or times, during the seasons, that a struggle will be maintained for ascendency, with a cessation of steady ventilation while it lasts. However, mining may now be said to have passed away from depending entirely on natural ventilation.

But it is asserted, especially by the more practical body of mining engineers, colliery managers, and others, that, in natural ventilation, the smallest shaft becomes the upcast, and maintains that position independently of surface temperature; and this idea is generally conceded. The effect of the tempera-

ture of the sides of the shaft has been brought forward in support of this—we will not say theory—but law.

It is said by those who allege that the sides of the shaft are the cause, that "the sides of a smaller shaft bear a much larger proportion to its total cubic capacity, than the superficial area of the sides, or heating surface of the larger pit, did to its cubic capacity; and as the strata, or sides of the pit, gave off a certain amount of heat, the air column of the smaller one will receive a larger increment of heat, and thus become the upcast." (*See* Vol. IX., pp. 248 and 249 of the Institute Proceedings.) However, we have seen that the sides of the shaft cannot be the moving power in the smaller shaft, if the air is always to travel in an undeviating course. The sides cannot raise the temperature of the air, when in summer it is warmer than the sides; and this supposition becomes untenable.

The fact, however, remains that the smaller shaft becomes the upcast, and gentlemen of experience, such as Mr. Wilkinson, and others, have no doubt about it; and it is an axiom of ventilation with them, that a proper proportion be maintained between the upcast and the downcast shafts.

He might here mention a case in his own experience bearing out this law. Three summers ago he was sinking a shaft, and had a 12-inch wood pipe in it, for ventilation. At the mouth of this pipe he had a 3-feet diameter fan driven by a belt from the winding drum, and blowing air down the pit through the 12-inch pipe. It was summer, and he felt annoyed at observing that, if the engine stood a little while, the smoke would come up the pipe, and out at the centre of the fan. His foreman sinker desired him to put the pipes into the engine chimney, saying at the same time that they would have steadier and better air by it, as he had always seen those pipes drawing up; so he connected the pipes with the engine chimney, and the air ascended, and the matter thus rested for about four months; after which, one frosty morning, he took off the bent pipe at the top of the pit which turned towards the chimney, and found the pipe drawing

up splendidly. He then poured water down the pipes, long enough to establish a stream of air flowing down them, and to bring the temperature of the air in the pipes as low as that of the surface air. There was then a good stream of air going down the pipes, to which he called the foreman's attention, and asked him what he had to say about the pipes always drawing up; he said nothing; but an hour or two afterwards he came back to him, and with a little self-importance said the air was coming back again up through the pipes. He thought that that experiment might be regarded as a fragment of evidence towards supporting the common occurrence that, where there are two shafts, or one divided into two parts, the smallest in either case was converted into an upcast.

If they were to accept it as an axiom in natural ventilation that where there are two shafts, or one divided into two parts, the smallest will become the upcast, there must be a reason for it beyond any that the writer has heard advanced; and the only reason he could give was that the greater volume of air, and consequent excess of weight, or expansive force, in the larger shaft, or larger division of a divided shaft, made it preponderate over the smaller shaft. They all knew that water will stand at the same level in two pits, having a communication between them, however disproportionate they are in size; but water is a non-elastic fluid, sitting, as it were, on the pit bottoms. There were nevertheless, phenomena in respect to water, that were not easily accounted for. At the mouth of the Bristol Channel, according to Airy, the whole rise at spring tides was 18 feet; while at Swansea it was 30 feet, and at Chepstow, situated further away from the moving power, the rise was from 50 to 60 feet; but in all estuaries and tidal rivers the tides were greater than on an even coast line. Now suppose they take a pit of 10 feet diameter, and another of 15 feet, the respective areas would be to each other as 100 is to 225. He thought it would be a difficult matter to show that 100 volumes of air would keep in a state of inertia 225 volumes, where both were standing upon, or meeting on a neutral line. But the disparity

in size of the upcast and downcast shaft might be far greater than that, and consequently the weight and volume of air in the two shafts.

But if they were to accept it as an axiom in natural ventilation that where there are two shafts the smallest becomes the upcast, the popular idea of having the upcast shaft larger than the downcast is opposed to natural ventilation, and also our definition of furnace ventilation; and the first work that a furnace has to do, when placed at the bottom of the largest shaft, is to overcome this natural law; hence the theory of the largest shaft for an upcast will always be working at that disadvantage.

Writers on this subject have been unable to lay down any definite rule as to the comparative proportions of upcast and downcast shafts. In a work he had seen, to which Messrs. Geofferer, Truran, Clay, Oxland, Fairbairn, Aitkin, and Picket were contributors, one of them, writing on ventilation, says: "The area of an upcast shaft, to afford a given amount of ventilation, as well as the proportion it should bear to the area of the downcast shaft, are subjects that have been discussed without any definite rule. In the upcast shaft of a coal mine, 300 yards deep and 200 acres in extent, one foot of area is usually allowed for every 1,000 cubic feet of air per minute which has to be passed up by furnace ventilation; but it is possible, under very favourable circumstances, to more than double that rate of ventilation. The natural ventilation of the Tyne Main Colliery gave 760 cubic feet per minute for each square foot area of shaft. By the highest furnace ventilation, this quantity was increased to 2,020 cubic feet. When the shafts of a colliery are of equal depths but of different diameters, natural ventilation ordinarily converts the smaller shaft into the upcast; but when the air is highly ex panded by a furnace, ventilation generally proceeds most easily by employing the largest shaft for the ascending air."

The writer here quoted takes the popular view, or, perhaps, has given the view that has become popular, of the shaft to be used as an upcast in furnace ventilation. It would have been extremely interesting if he had given the comparative areas of the

upcast and downcast shafts at the Tyne Main Colliery, where 760 cubic feet of air were obtained per minute for each square foot area of the upcast shaft by natural ventilation. However, general experience settled which shaft was to be the upcast, and the inference from what the writer above quoted says of natural ventilation, supports that experience.

The theory of the largest shaft for an upcast was, however, very generally embraced. In Vol. VIII., page 269, of the Institute Proceedings, it was stated that " Where one shaft is sunk of greater area than the other, the larger one should be chosen for the upcast, because the increase of friction due to the higher velocity, as a result of the expanded bulk of the upcast air, was greater than the decrease of friction due to lessened density entailed by its higher temperature." The author of the above, recommended that the largest shaft should be the upcast; but the writer had as yet failed to grasp the weight of the reason that he gave for his conclusions.

The principle of having the largest shaft for an upcast was greatly outraged at the Old Oaks Colliery, near Barnsley, where he was told that they had four downcasts to one upcast—viz. two downcasts 7 feet 6 inches each, 298 yards deep, and two 12 feet diameter, at the New Oaks, 337 yards deep. The upcast was 10 feet diameter and 297 yards deep. The aggregate of the squares of the diameters of the downcasts was 400·5 feet; and the square of the diameter of the upcast was 100 feet, giving the ratio of the area of the upcast to that of the downcasts of 1 to 4. The ventilation passing this upcast shaft was 290,000 cubic feet per minute; 270,000 in the return air-way, and 20,000 taken from the downcasts to supply the furnace. The water-gauge was from 7 to 9-10ths of an inch. Those facts had all been verified by the Government Inspector of Mines, who had been there and measured the ventilation.

The air must travel at the rate of 61 feet per second in the upcast to produce that ventilation, or 41 miles an hour; considerably above the velocity of a gale.

It would be interesting to know why they did not turn two

or more of their downcasts into upcasts at the Old Oaks Colliery or whether they consider it better to have only that one shaft for the upcast to produce such an immense current of air.

At the Glasgow School of Mines, where it was necessary that something like definite rules should be laid down on the subjects taught, the rules in reference to furnace ventilation were—if a shaft was sunk exclusively for an upcast, it was in its best relation if it was one-third the area of the downcast; this is greater than the practice at the Oaks Collieries. Whatever was the Professor's reason for that proportion between the upcast and downcast shaft he could not say, but believed that he said it was the result of experiment. It was, however, taught in the full knowledge of what was said to be the contrary in the book he had quoted from, as that book was used at the school for reference. The furnace was to be placed about 30 yards back from the shaft, with a rise, if practicable, of one in six to the shaft. The drift to be made as dry as possible, and well lined with firebrick. The furnace to have about a foot area for every foot area of upcast. The furnace-bars to be placed such a distance from the floor as to keep them moderately cool; a little water in the ashpit commendable. Care to be taken to protect the strata surrounding the furnace, or furnace drift, where coal or carbonaceous shale was near. That packing would serve the double purpose of preventing the strata taking fire, and equalising the pressure on the arch where there was "creep." An inner arch was also to be erected with a few inches of space between, and carried back a few feet beyond the furnace, so as the arch supporting the strata might be preserved from the action of the fire.

If the coal was yielding gas to such an extent as to foul the return air to the explosive point, then a dumbdrift was to be made, and the furnace to be fed in such a case with fresh air direct from the downcast; the dumbdrift not to be less than 20 yards above the furnace.

The rules as to the working of a furnace were that every

degree of heat added to the air expanded the volume affected by it, 1–459th part; hence, in a pit 459 yards deep, if the furnace increased the return air one degree, in the upcast shaft, the work due to the furnace would be equal to one yard deep of air, the area of the shaft; which weight would be increased similarly for every degree of heat the furnace added. Ventilation was in direct ratio to the square root of the difference of temperature between the upcast and downcast shaft; thus, if the ventilation of a mine was 60,000 cubic feet per minute, created by a difference of temperature between the upcast and the downcast shafts of 64 degrees, by increasing the temperature to 81 degrees the ventilation would be increased as 8 was to 9, or from 60,000 to 67,500.

The resistance to the air would be as the square of the velocity; and here they saw the practical nature of the subject. Suppose they had 60,000 cubic feet per minute, by a difference of temperature between the up and downcast shafts of 60 degrees, and that difference is increased to 81 degrees, it does not follow that the ventilation would be increased as 8 was to 9, or to 67,500 cubic feet. It may be granted that the furnace had increased the temperature to 81 degrees, but all the former relations to its work would be altered. It had got 7,500 cubic feet of air per minute more to drag along, which, with a return airway of 50 feet area, would require the air to travel 2·5 feet per second quicker, making the squares of their comparative velocities as 400 is to 506·25, so that the ventilation would be as 8 to 9, less the loss by increase of friction.

But it was asserted that there was a point beyond which the temperature of an upcast could not be increased effectively—that, beyond a certain limit, it became detrimental and retarded ventilation. From experiments made at Dowlais, recorded in Vol. VI., p. 130, of the Institute Proceedings, it was found that the greatest amount of air was passed through the furnace when the heat of the shaft, or stalk, was up to about the point at which lead melted, or 625 degrees.

At 700 degrees it was considerably less; and at the temperature that cast iron could be melted, the air that passed was insignificant. Those experiments were conducted by Messrs. Dickenson, Atkinson and Evans, and they gave it as their opinion, that the "expansion of air by high heats produced such a drag on the sides as prevented an upward current."

From all the evidence that the writer had been able to collect, he was unable to give any definite rules for the relative sizes of upcast and downcast shafts, or clear up other difficulties connected with the subject, which he thought must be left to a more extended experience of the subject. Some of the reasons for supporting the theory of the smallest shaft for an upcast seemed to be that it was the natural course for the ventilation to travel; that the effect of the furnace was more uniform throughout the whole shaft; that the average temperature was higher, probably arising from the velocity being greater; that the discharge of the air at the top of the upcast, at a comparatively high velocity, lessened the distance and created, as it were, an upcast above the surface. That there was the example and experience at the Oaks Colliery, of four downcasts to one upcast, in proportion of area as one to four, where a very high ventilation was maintained. That the proportion of one to three, taught at the Glasgow School of Mines, was corroborated in practice by Mr. Wilkinson and others. That if an excess of weight in one shaft produced and maintained natural ventilation, it appeared most reasonable that that excess ought to be maintained whatever system of ventilation was adopted.

Let them suppose an upcast pit of 100 feet area and a downcast of 300 feet, each 459 yards deep, which would give (at 80 lbs. weight for every 1,000 cubic feet of air) in the smallest shaft within a small fraction of five tons, whilst there would be some fifteen tons of air in the downcast or larger shaft. If such an excess of weight was set in motion, it would drive the air before it, like the tides of the Bristol Channel, that heaps its waters higher and higher the further it goes from the moving force.

The advocates for the largest shaft for an upcast, wish to do away with the friction of the highly expanded air as much as possible, and it appears that only in that respect does the system claim any precedence. The difficulties that might arise with that system were as follows:—Did rarefied air produce as much friction as unrarefied air? or was its elastic pressure and consequent friction not in proportion to its density? It seems also, only to recognise the friction that was due to the travelling current after it has been heated and passed the furnace; whereas by a smaller downcast there would be friction and attenuated air before the furnace also; so one difficulty appeared to be got rid of by creating another, and brought up the question of which side of the furnace ought the friction, or the excess of friction, to be on? Certainly nothing was gained by increased speed in the air current before the furnace, for it was all loss there, but in the upcast, or behind the furnace, gain would result from the air travelling further before parting with its heat, and consequently filling the upcast with a body of lighter air. But the practice at the Old Oaks Colliery, with its results, seemed to contradict the large shaft theory, whilst the practical tests at Dowlais, showing that at very high temperatures the air travelling through the chimney, or experimental upcast, was "insignificant," must not be ignored; but he thought that such a test was not so authoritative as the daily work of an air furnace such as that at the Old Oaks Colliery.

They might all have seen carbonic acid gas and also light carburetted hydrogen gas get into places, and have experienced great difficulty to penetrate and eject them, and it was very probable that in those experiments, the decomposition of fuel at such a high temperature, and probable decomposition of the sides of the furnace and chimney, generated dense gases, which took possession of the air passage, and prevented the atmospheric air from penetrating them. Air so expanded as to retard its ascent, or practically to stop it, as in the experiment referred to, appeared to be a contradiction. The more air was

expanded, the lighter it became bulk for bulk, compared to air in its normal state; and the result of such expansion must be a greater difference in the weight of the air in the up and down-cast shafts, and consequent increase to the power of the furnace for ventilating purposes.

PROCEEDINGS.

12th January 1877.

The Nineteenth Annual General Meeting of the Institute was held at the Castle Hotel, Merthyr Tydfil, on Friday, the 12th of January 1877;

Mr. JAMES MURPHY, Assoc. Inst. C.E., Vice-President, in the chair.

The Minutes of the last General Meeting were read and confirmed.

ELECTION OF NEW MEMBERS.

The Chairman announced that the Ballot Lists had been opened by the Scrutineers, and declared the following gentleman to have been duly elected as a Member of the Institute, viz. :—

Mr. Edwin Southwood Jones, Mining Engineer, Pontypool.

ADMISSION OF NEW MEMBERS.

The following gentlemen, elected at previous Meetings, were then formally admitted to the Institute by the Chairman, and signed the Roll Book, viz. :—

Mr. Wm. Thos. Williams, Aberdulais.
„ E. R. Williams, Cwmtylery.

Mr. James Bell, Cardiff.
„ John Thomas, Resolven.
„ Theodore Vachell, Cardiff.
„ Thomas Jones, Cwmtylery.

ANNUAL STATEMENT OF ACCOUNTS AND SECRETARY'S REPORT.

The CHAIRMAN laid before the Members the following Financial Statement and Report of the position of the affairs of the Institute for the Session 1875-76, ending 29th October 1876 :—

SOUTH WALES INSTITUTE OF ENGINEERS.

FINANCIAL STATEMENT, SESSION 1875–76.

Receipts up to 29th October 1876.

	£	s.	d.
By Balance, 29th October 1875	314	14	0
„ Cash received from Members	434	14	0
„ Dividends, Midland Railway Stock	30	6	7
„ Sale of Books	6	15	1
„ Interest from Bank	5	4	10
„ „	5	2	10
„ Cash from Members in repayment of advances on Lancashire Excursion	69	19	11
Total	£866	17	3

Audited and found correct,
the 12th day of January 1877,
G. F. Adams, *Auditor.*

Expenditure up to 29th October 1876.

	£	s.	d.
To Printing and Stationery	71	17	8
„ Engraving	81	13	3
„ Reporting	12	12	0
„ Secretary	80	0	0
„ Sundries	82	12	6
„ Midland Railway Stock	80	0	0
„ Advanced on account of expenses Lancashire Excursion	90	1	4
„ Balance	368	0	6
Total	£866	17	3

GENERAL STATEMENT.

Assets up to 29th October 1876.

	£	s.	d.	£	s.	d.
By Balance brought down		...		368	0	6
„ Midland Stock	649	13	2			
„ Ditto Preference Shares	95	0	0			
				744	13	2
„ Books, due for		...		36	9	5
„ Subscriptions due to 29th October 1876	275	2	0			
Less irrecoverable	68	5	0			
				206	17	0
„ Due on advances, Lancashire Excursion		...		20	1	5
Total				£1,376	1	6

Liabilities up to 29th October 1876.

	£	s.	d.
None.			
To Balance	1,376	1	6
Total	£1,376	1	6

REPORT.—Session 1875–76.

The accompanying Financial Statement shows the general position of the Funds of the Institute at the close of last Session, ending 29th October 1876, to have been as follows, viz. :— The sum of £649. 13*s.* 2*d.* stood invested in *Midland Railway Consolidated Stock*, and also the sum of £60 in *Five per cent. Perpetual Preference Stock*, and £35 *New Four-and-a-half per cent. Preference Shares* of the *Midland Railway*. The *dividends* on railway stock amounted to £30. 6*s.* 7*d.*, or nearly 4¼ per cent. during the year. The amount received and due for *books* sold was £42. 4*s.* 6*d.* The *interest* received from the bank amounted to the sum of £10. 7*s.* 8*d.* The amount received and due for *Members' subscriptions* was £641. 11*s.* 0*d.*, and the *balance* brought forward from the last Session amounted to £314. 14*s.* Those sums together gave a *total credit* of £1,784. 16*s.* 11*d.*

On the other side, *General Expenses* were paid to the amount of £328. 15*s.* 5*d.*, and the sum of £45 had been *invested* in *Midland Five per cent. Perpetual Preference Stock*, and £35 in *Midland New Four-and-half per cent. Preference Shares*, leaving a *balance* in favour of the Institute of £1,376. 1*s.* 6*d.*, of which sum £368. 0*s.* 6*d.* was represented by *cash* at the Bankers'.

During the past Session the Institute has lost two of its Members, in the demise of the late Mr. R. S. Roper, of Newport, and the late Mr. Lionel Brough, F.G.S., H.M. Inspector of Mines for Gloucestershire and Somerset; the latter was one of the earliest Members of the Institute, having been President in 1860–61, and took an active interest in its welfare, ever upholding the value of technical and scientific knowledge combined with practical experience in the conduct of mining operations, as tending to the greater safety and more economic working of the mines and the removal of many of those dangers inherent thereto.

During the past Session also, eight Members have resigned, and three have had their names taken off the Roll Book in accordance with the 14th Regulation. During the same time,

twenty-two names have been added to the list of Members, which now comprised :—

	188 Members.
	4 Associates.
	15 Graduates.
Total . .	207

During the past Session, the first excursion of the Members of the Institute to any distance was organised ; and, accompanied by the President, some forty of the Members visited several of the collieries and works in Lancashire, where they were received with the utmost cordiality, and derived great pleasure and interest from studying operations in that district. The excursion took place in June, and extended over four days, when the following collieries and works were visited, viz. :—

First day—*Wigan District.*

The Ince Hall Coal and Cannel Company's Collieries—Coal washing, screening machinery, chain-haulage, &c.—

The Rosebridge and Douglas Bank Colliery Company's Collieries—Coal workings 810 yards deep ; fine winding engines and machinery—

The Wigan Coal and Iron Company's extensive Collieries and Ironworks—Coal washing, chain and rope haulage, winding engines and other machinery, &c.—

The Pemberton Colliery, belonging to Messrs. Blundell & Company—Very fine winding engines and general surface arrangements.

Second day—*Manchester District.*

Sir Joseph Whitworth & Company's Engineering Works.

The New Town Hall—Built at a cost of upwards of one million sterling—

The Collieries of the Bridgewater Trustees — Fine engines, machinery, and surface arrangements, coal washing, &c.—Underground canals for conveyance of coal from the coal workings—

The Collieries of Messrs. Andrew Knowles & Sons, Limited—Pendlebury, Agecroft, Clifton Hull, and Pendleton Collieries.

Third day—*Hyde Junction.*

The Boiler and Engineering Works of Messrs. Daniel Adamson & Co.—Boilers constructed by machinery, with drilled rivet holes, and machine-riveted seams and joints; flanged and welded tubes; the whole most complete and effective—

The Astley and Duckinfield Deep Pits, belonging to the Dunkirk Coal Company—

Large Cotton Mills—Driven by engines of 670 and 550 horse-power respectively, and having triple and quadruple compound steam cylinders—

Ditto—*Burnley.*

The Collieries of the Executors of John Hargreaves, at Burnley—Bank Hall and Rowley Collieries; Endless chain haulage and coal winding, coal washing, &c.—

The Townley Colliery and Fireclay Works, belonging to Messrs. Brooks & Pickup — Endless chain haulage, coal washing, new coke ovens, fire brick and pottery works.

Fourth day—*Barnsley District.*

The Dodworth Colliery—Underground haulage, coal washing, &c.—

The Oaks Colliery—Ventilation about 250,000 cubic feet per minute—

The Corton Wood Colliery — Pits tubbed 20 feet diameter. New plant, &c.—

The Hoyland Silkstone Colliery—Silkstone seam first won under the Barnsley bed at a depth of 520 yards.

ELECTION OF OFFICE-BEARERS FOR THE SESSION 1876–77.

The CHAIRMAN declared the following Office-bearers, nominated at the last General Meeting to succeed those gentlemen retiring by rotation, to be duly elected, viz. :—

Vice-Presidents.

Mr. Thomas Joseph.
„ George Wilkinson.

Members of Council.

Mr. George Brown.
„ H. V. Trump.
„ James Barrow.
„ James Colquhoun, F.G.S.
„ Wm. G. M'Murtrie, F.G.S.
„ Arthur J. Stevens.

Secretary.

Mr. Hort Huxham, F.G.S., M. Inst. C.E.

The discussion of Papers read at previous Meetings was then proceeded with.

The CHAIRMAN said that the President had written from Palermo expressing his great regret that he was unable to return to England in time to be present at the Annual Meeting. He (the Chairman) had therefore been called on to preside; and as it might be sometime before he again had the honour of occupying that chair, he would say a few words before proceeding with the discussion of Papers.

For the last few weeks they had been passing through a series of immense atmospheric disturbances which had been spread over very large areas. Possibly they had fared better than in many parts of the country, but they had to lament one of those unfortunate accidents to which every colliery district was subject, in the late colliery explosion at Abertillery. He thought, however, that the records of those terrible disasters would show that of late years they have become more and more infrequent in the district, owing to the great amount of practical and scientific attention paid to the important question of ventilation and to the better discipline maintained in most of the fiery collieries in South Wales.

The Iron Trade, as all of them knew, had been and still continued in a very depressed condition, but in that respect South Wales had not been singular, for similar reports had come from Yorkshire, Lancashire, Scotland, and other districts; and although of late there had been some very slight improvement in the North, it was not apparently sufficient to give any immediate encouragement of better trade. He thought that the importation of Belgian iron into this country indicated that the cost of the home production compared unfavourably with that of Belgian iron; and probably that might to a great extent be accounted for by the lower scale of wages paid in Belgium, where, for instance, a fitter would receive only 25 francs for his week's labour, instead of 32*s.* paid to the English artisan of the same class; and he was informed that the difference in the labour cost alone in the manufacture of a locomotive amounted, at one time, to between £300 and £400 against the English manufacturer. As long as that was the case it would be the duty of managers to reduce wages so far as they could, but at the same time to increase, if possible, the comforts of their workmen. The Belgian workmen were not in the habit of drinking, and, as a rule, lived cheaper than Englishmen.

From recent statistics of the exports of coal it would appear that there never had been a time when such large quantities had been sent out of the country; and although it was more than probable that the financial return to the colliery owners had been very low, it looked as if the coal trade were becoming the great staple trade of the country. The population of the world was increasing at the rate of 17 millions a-year, and from that fact alone there was a strong inference that the demand for coal must continue to increase.

At the present time there were some great engineering works in progress, two of which (the Severn Tunnel and the Severn Bridge) would notably benefit the coal districts of South Wales and the Forest of Dean, in opening up a shorter route to London and the South-west of England. Both those works would afford much interest to the engineer in watching their progress.

He was sorry to find that, in consequence of the unavoidable absence of the authors of the three first Papers, it might be desirable to postpone their discussion until the next meeting. He would suggest in respect to Mr. Bassett's Paper that he should be asked to furnish by the next meeting a Plan and Section showing the country, the line of the main pipes, and the lengths to which they were to be carried.

The discussion of the following Papers was accordingly adjourned to the next meeting, viz. :—

On "The Pencoed, Mynydd-y-Gaer, and Gilfach Goch Mineral District," by Mr. Henry K. Jordan, F.G.S.

On "The Drainage of the Taff Vale District," by Mr. Alexander Bassett, M. Inst., C.E.

On "The Bryncethin and Ogmore Valley Mineral District," by Mr. George Birbeck.

Adjourned Discussion on "Personal Experiences in Colliery Explosions and with Standing Fires."

The Chairman said that the next Paper for discussion was that of Mr. George Wilkinson, on "Personal Experiences in Colliery Explosions and with Standing Fires." He thought it was a most important contribution, inasmuch as the Paper was a record of actual experiences of the writer over many years, and that fact alone made it doubly interesting to those who were engaged in the management of collieries, as it dealt largely with accidents, their causes and remedies.

Mr. A. J. Stevens said a description had been given of the use of Gurney's method of extinguishing underground fires by carbonic acid gas, and in the discussion which followed Mr. M'Murtrie instanced a case in which he had driven carbonic acid gas down the pit, through a pipe, by means of a steam jet, and thus flooded the workings with that gas; he did not, however, understand how Mr. Wilkinson, in the case that he had referred to, obtained sufficient draught to draw the carbonic acid gas from the furnace he built underground into the workings already filled with air, for it appeared he had no power with which to drive it in the workings in the same manner as Mr. M'Murtrie had.

Mr. Wilkinson said that the colliery workings were properly ventilated before the fire occurred, and there was a separate intake for the air going into the workings, and a separate return, or outlet, through which the current of air constantly travelled. He first contracted the "outlet" to one-third its regular size, and afterwards built a furnace in the "intake," stopping it up completely, with the exception of an orifice for a 12-inch pipe, through which he passed the products of combustion in the furnace fed with coke and limestone (that was, pure carbonic acid gas) into the workings. The ventilating power previously established at the colliery was sufficiently powerful to draw the gas into the workings for some three consecutive days, when it became

apparent that they had become filled with it; after which the intake and outlet were sealed up.

Mr. R. BEDLINGTON inquired whether it was supposed that the carbonic acid gas had displaced the whole of the air in the workings, for unless that had been so he did not see how the carbonic acid gas could have put the fire out; he would also be glad to know, when the outlet was opened, what was noticed to come off.

Mr. WILKINSON said it would be remembered that for three whole days nothing but carbonic acid gas passed into the workings, and there was every reason to suppose it had filled them in every part; he then closed the outlet, and waited a few days until no more carbonic acid gas passed into the workings before sealing up the intake. When some time afterwards the outlet was opened, pure carburetted hydrogen gas came out very strongly, so as to prevent their working for a time, but nevertheless it was found that the fire had been extinguished. The workings so treated and sealed up extended over seven or eight acres, and were about 1,000 yards from the downcast pit. There was a separate intake through a " hard " heading of about 300 yards into those workings, and one air pit as the outlet, so that the workings could be completely shut off at those two points and rendered air-tight. The greater portion of those workings were to the rise, and the fire occurred about 150 yards off the level. The air pit was placed about the middle of the workings to the rise.

Mr. C. H. JAMES considered that there would be great difficulty in forcing the carbonic acid gas up to the rise, so as to displace the atmospheric air, or lighter gases. He would like to know the thickness of the seam, and the inclination of the strata at that point.

Mr. WILKINSON said the workings were in the "Nine Feet" seam, and the inclination was about $2\frac{1}{2}$ inches on the yard. It was a curious fact that, although carbonic acid gas was poured into the workings for three days before sealing them up, upon their being opened, carburetted hydrogen came out so strong that it drove them back and overpowered some 20,000 cubic feet of fresh air per minute which they had with them.

Mr. R. BEDLINGTON inquired as to the extent of the fire, and whether it was principally on the coal face, or in the shale above; and whether it broke out into flame, or only smouldered in the small coal and rubbish.

Mr. WILKINSON said the fire occurred in a goaf between two roads of a double stall, resulting from a blower in the bottom having lighted and set fire to the small coal and rubbish, a few days before. It did not, so far as they could see, break out into flame, but smouldered and burnt away in the small coal and rubbish, which he usually observed burnt much better and stronger than coal in such places.

The CHAIRMAN asked whether there was any doubt in the minds of gentlemen present that fire could be extinguished by carbonic acid gas.

Mr. R. BEDLINGTON thought it might be a difficult thing to accomplish.

The CHAIRMAN considered that possibly it might, but he thought that the properties of the gas and the experience in its use quite warranted its employment in very many cases to extinguish underground fires. He remembered that the great fire at Ardsley Colliery, near Wakefield, was most successfully put out by means of carbonic acid gas. With reference to the question whether the carbonic acid gas entered into and displaced all the air in the workings, he thought that when the inlet and outlet were effectually sealed, so as to prevent the further ingress of any supplies of oxygen by the atmospheric air, the fire must of necessity, after consuming any small supplies of oxygen contained in any air left in the workings, die out and exhaust itself, from a sheer want of that which alone could enable combustion to proceed; and therefore it was not very material whether a little air was left in the workings, so long as they were effectually sealed up, to prevent the access of any further supplies.

Mr. R. BEDLINGTON said that, as Mr. Wilkinson had had experience under very difficult circumstances, he would ask

him whether he considered it preferable to fill the workings with carbonic acid gas, or to simply cut off the supply of air, leaving the products of that combustion to assist in putting the fire out?

Mr. WILKINSON had dealt with fires which he had sealed up so as to exclude access of fresh air, and no doubt where that could be accomplished it would eventually extinguish the fire, but it generally took a long time, and in one case he had had a fire burning for ten years, although completely isolated from the air. It must be remembered that when the air was altogether excluded there was no agent to cool the heated strata, and it was astonishing how long the ground retained heat in such cases. He had known places retain the heat for three to four years after the fire had been extinguished. In some cases the use of carbonic acid gas had proved thoroughly successful, and he thought that was an effective and probably more rapid mode of putting out fires than merely shutting off the supply or access of fresh air. In the case he had quoted, the carbonic acid gas had to go about 150 yards to the rise to reach the fire; he believed the rise workings above were full of carburetted hydrogen, for whilst they were pouring in the carbonic acid gas explosions frequently took place, and, as he had stated, on re-opening the workings, after the fire was extinguished, carburetted hydrogen alone came out in large volumes. In the case of some fires it would probably be better to convey water down the pit in pipes, under considerable pressure, say of 100 to 150 lb., and fight it out with the hose inch by inch. He considered that, however, to be very laborious work, and extremely dangerous. He had also tried to smother a fire with steam, but unsuccessfully, as he found that wherever steam would penetrate it was invariably accompanied with supplies of air, which it was impossible to exclude under such circumstances.

Mr. R. BEDLINGTON concurred with Mr. Wilkinson in the great danger attending any attempt to put out fires with the hose, especially with the probability of explosive gas being within reach, or not far away from the fire.

Mr. C. H. JAMES referred to page 72 of the last Proceedings, where Mr. Bedlington had stated "that the increased atmospheric pressure, when the barometer rose, forced the gas back again into the fissures and pores of the strata from which it had exuded," and said he thought it should have been stated that the increased pressure "kept the gas back," rather than "forced it back." He also questioned the existence of "pores" in the coal or strata, and could not imagine any coal, a lump of which, if placed in a vessel charged with gas and the pressure increased to such an extent as was indicated by any known variation of pressure of the atmospheric column, could be made to absorb any appreciable quantity of that gas.

MR. R. BEDLINGTON thought that if a greater issue of gas took place, when the barometer was falling, from a reduction of the pressure, it was clear that when an increase of pressure took place with a rising barometer, and the gas returned, it was consequent upon the increase of pressure forcing it back. He was probably wrong in using the word "pores;" he had meant the fissures, slips, crevices, or other passages through which the gas was liberated or exuded from the coal or strata, and he thought that everyone must acknowledge it to be a reasonable supposition that where gas was found to issue through such channels under a reduced pressure or a falling barometer, with a return or increase of such pressure, the gas would be forced back to where it came from. At all events that was his belief and the result of his experience, and he thought also it was that of Mr. Wilkinson and others.

Mr. WILKINSON entirely concurred in what Mr. Bedlington had stated. He had seen an unventilated goaf of some forty acres in extent from which any outflow of gas was carried away by a return airway. With a high barometer, no gas would be found in that goaf, which could then be safely traversed with a naked light, but upon the barometer falling one inch, equal to a reduction of pressure of about 70 lb. to the square foot, the gas filled the forty acres of goaf and poured out through the return airway; and again, when the barometer began to rise, the outflow of gas

ceased, and as it gradually regained the fall, the gas retreated back in the goaf until the inch of fall in the barometer having been regained, and the original pressure restored, the whole forty acres of goaf would again be entirely clear of gas, as before. If, upon the restoration of the atmospheric pressure, the gas had not been forced back into the fissures and crevices of the coal and strata from whence it had come, he would ask what had become of it, or where had it gone to? for there was no outlet for it, except through the return airway, which, together with the entrance to the goaf, became free of gas very soon after the barometer began to rise, and whilst the greater area of the forty acres of goaf was still full of gas, which kept gradually retreating before the increased pressure. If the pressure taken off let the gas out, why should not the return of the pressure force it back again? He also remembered in a sinking pit, which had been walled with brick from the surface, a fissure was met with in the strata at a depth of 35 yards, from which pure carburetted hydrogen gas always came out with a south wind, but as soon as the wind veered round towards the north the outflow of gas ceased, and a strong inward draught was created sufficient to draw the flame of a candle into the fissure, and that without any apparent cause or any means of judging how such inward current was produced and where it went to.

Mr. JOHN SMITH said that his experience and observation entirely accorded with that of Mr. Wilkinson and Mr. Bedlington, and he considered that, with a rising barometer and return of atmospheric pressure, the gas was forced back into the coal and strata through those channels from whence it came.

The CHAIRMAN asked whether Mr. C. H. James wished it to be understood that coal could not be charged with any more gas than it contained in its normal condition, and that if a block of coal were placed in a vessel full of gas and pressure applied, the coal would not absorb any of the gas.

Mr. C. H. JAMES did not wish that to be understood, but only that the ordinary variations of pressure in the atmospheric column would not be sufficient to produce such an effect; he thought a much higher pressure would be necessary.

Mr. G. J. JEE considered that it would require immense pressure to force the gas into the coal itself.

The CHAIRMAN, referring to the remark of Mr. Wilkinson that he had failed to put out underground fire by flooding it with steam, said that from his personal observation of the action of fire-engines throwing water on large bodies of fire, it appeared that in no instance where there was a large body of fire to be dealt with, as at the burning of the Custom House at Dublin, the fire in Tooley Street, London, and other similar cases, had the water succeeded in putting out the fire, but that it burned itself out, and all that could be done in such cases was to save adjoining property from taking fire. He conceived that arose from the water being converted into steam when thrown on the incandescent mass before it actually came in contact with the burning materials; the steam also was decomposed by the action of the heat, and increased the intensity of the fire by the oxygen thus supplied. If, however, a sufficient body of water could be thrown on the burning mass he had no doubt it would put the fire out, but small quantities of water were, in his view, not only useless, but tended rather to increase the evil. He imagined that possibly a similar effect might take place when steam was attempted to be used to extinguish underground fires.

Mr. R. BEDLINGTON asked whether it was thought that if the Colliery workings were completely flooded with steam it would put out a fire therein.

Mr. R. WILKINSON said that provided pure steam could be sent into the workings so as to fill them, it would undoubtedly produce a good effect in extinguishing a fire, but it was almost impossible to flood the workings with steam without at the same time sending in a quantity of air, and he did not think that mixed steam and air would put out a fire. He had failed in the use of steam because he could not exclude the atmospheric air.

Mr. W. G. M'MURTRIE mentioned the case of a colliery where the upcast and downcast shafts were about 160 yards in depth, and some 12 yards apart. A fire broke out in an old stall, at a

short distance from the bottom, smoke and flame ascending the upcast shaft. By and by smoke crept up the downcast shaft also. Flooding the colliery was thought of, but as the pumps had enough to do, this was reserved as a last resource. The top of the upcast was reduced, so as to leave an opening only just sufficient to maintain an upward current. The downcast shaft was divided by a brattice, and by letting water fall down on one side, the downcast pit was converted into a down- and upcast, which enabled the men to get some way further down. The brattice, however, in the lower part not being tight, this had to be abandoned. The upcast was afterwards thrown wide open, and ample water sent down both sides of the downcast. A fire-engine from a neighbouring town was obtained, and worked at bank, the hose being taken down the shaft, and length added to length until the seat of fire was reached. The colliery was a valuable one ; and through the energetic efforts of the manager and a band of willing assistants the fire was eventually extinguished in the manner described, but not until considerable damage had been done to the pumps in the upcast. The application of carbonic acid gas was contemplated, but the time required to complete the necessary arrangements was deemed too long.

Mr. Huxham, referring to the action of steam on fire, said that there was a well-known laboratory experiment for decomposing steam into its elements of oxygen and hydrogen, which was done by placing a tube, filled with iron borings and filings, through a small furnace, in such a manner that it would get red-hot for some distance along its centre; steam was then introduced into the tube at one end, and had to traverse through the red-hot borings to find an exit at the other end; but in its passage through the tube the steam was decomposed by the affinity of the red-hot iron borings for the oxygen it contained, and in consequence free hydrogen only escaped from the end of the tube. Many years ago also patents were taken

out for the use of steam in combination with the blast in blast-furnaces; it was contended that the steam would be decomposed on reaching the incandescent mass inside the furnace, and thus afford a supply of free oxygen and hydrogen, which would materially assist and economise the fuel.

Mr. R. Bedlington said that as many Members were not present who might wish to have the opportunity of expressing their opinions on the subject-matter of the Paper under discussion, he suggested it would be advisable to postpone its further discussion to the next meeting.

This being agreed to, the further discussion was accordingly adjourned to the next meeting.

In consequence of the absence of Mr. Hugh Begg, the discussion of his Paper on "Natural and Furnace Ventilation" was postponed to the next meeting.

The Chairman said that as they had had a somewhat protracted discussion, their time had run too short to read the Papers that were on the programme for that day, and therefore he thought it would be better to take the following Papers as read, so that they might be printed in the Proceedings by the next meeting, viz. :—

On "Coal Washing," by the President.

On "The Cwm Carne Reservoir," by Mr. George John Jee.

A vote of thanks to the Chairman closed the proceedings.

ON

COAL WASHING.

By the President—James Brogden, Esq., F.G.S.

It was not very long since that a large quantity of small coal was thrown away by the colliery proprietors in the North of England. The very heaps into which it was put were costly in several ways: ground had to be paid for, and the charges incurred for tipping &c., together with the blocking up of the space available in the immediate proximity of the colliery, made it a serious matter beyond the loss resulting from having worked and raised the coal, which, though in a state of dust, was well known to contain when pure the same elements of heating power per unit as the large coal which had preserved its size.

It was evident, then, to the scientific and practical mind that an enormous waste was occurring. The small coal, when burned, produced more clinker and ash than the large, apart from its being more difficult to consume rapidly, on account of the impossibility of the air freely traversing the bulk, and thus allowing combustion to take place at once. Theoretically, the value of coal consists in the units of heat that it contains; the practical manner of extracting this being another part of the question. Pure and clean small coal is theoretically as valuable in this respect as large; but mixed with impurities, such as are usual, its value is very much deteriorated, crudely in proportion of 1 to 3 of impurity. That is perhaps better exemplified by saying, that one ton of coal used in the blast-furnace would be

lost in neutralising the effect of three tons of impurities; but when the coal is reduced to coke that loss becomes even more serious—as would be seen hereafter. It would appear very odd that a simple and well-known practice, carried out for long periods of time and applied to the working of the more valuable minerals, should have escaped the observation of keen-sighted and scientific men until comparatively a recent date.

The application of differences in the specific gravities of the bodies of which the heap was composed settled the question of difficulty after a medium was found which enabled these to be resolved rapidly.

In the case of gold, tin, copper, lead, &c., the ores are crushed to powder, water is run down with the pulverised material, and, passing over ripples, the heavier portions settle to the bottom, and the quartz, &c., being lighter, passes away. The gold, &c. is then collected at the bottom of the ripples.

Nature on a large scale has carried this out in the distribution of the gold and tin in Australia; in what are called the wash-drifts, the gold and tin are invariably found at the bottom of the washes, the heaviest nuggets being nearer the gold and tin reefs, the finest carried to the furthest distance.

It will be seen that gravity has been the force which has so effectually operated in the example above mentioned; and in coal washing we may look to the same effect, only that we must exactly reverse the operation, as the impurities mixed with the coal have generally a greater specific gravity than the coal itself: they generally consist of

Shales
Iron Pyrites
Carbonate of Lime
Carbonate of Magnesia.

The useful portions of the coal for heating purposes are generally combined chemically and separately from the above-mentioned impurities, hence the advantage to be gained by separation. Washing the coal on the same principle as carried

out with the metals would float away the coal, leaving the pyrites and heavier impurities in the bottom of the ripples. If these could be cleared periodically, clean coal would be the result, and the operation could be made continuous. This principle has been carried out, as will be shown a little later on.

Pure fuel, especially when it has to be intimately mixed with metallic products, is of the greatest importance. If therefore, we do not at once separate the gaseous products of the fuel and use them, we can only attain the end in a crude way by washing out the impurities as far as possible; but we must never forget that a varying quantity of from 2 per cent. to 5 per cent. of what is generally shown as ash will remain in the coal which is thus treated.

Take the case of an ironworks; the fact is, the importance of having a pure fuel for smelting purposes can hardly be over estimated. On this, in a great measure, depends the regular working of the blast-furnace and the quality of the iron produced. To obtain certain, constant, and satisfactory results from the furnace when a large percentage of the so-called fuel consists of shales, pyrites, fireclay, stone, &c. is almost impossible, and every effort should be made to obtain coke as free from these substances as it can be had. In many instances, small coal can be got from the colliery sufficiently clean to be used to advantage without the shale, &c. being separated from it.

The table referred to further on, and marked A, gives examples of the proportions of coke and shale to 100 parts of so-called coal when used without washing; 30 cwt. of coal being allowed for the production of one ton of coke.

Several plans have been devised to effect the separation of the coal from the impurities mixed with it when sent from the colliery; but most have failed to accomplish the object sufficiently well without incurring a considerable waste of fine coal, heavy cost in wages, and the fouling of a large quantity of water. The latter objection was a very serious one, and in many places coal washing has had to be dis-

continued, consequent on legal proceedings having been taken against the colliery proprietors for polluting the streams. By a system of filtration, however, the objection has to a large extent been overcome.

The method of manipulating and washing coal, as now applied in many cases in the North of England, the Barnsley, Wigan, and other districts, consists in first putting the coal from under the colliery screens over a high screen, whereby the nuts and the duff coal are separated; the duff coal is mixed with a stream of water, and is run down a trough some 14 inches to 18 inches in width, at an inclination of about $\frac{1}{2}$ inch to $\frac{3}{4}$ inch to the yard; in it are placed several boxes below the level of the bottom of the trough, and a valve is placed in the bottom of each box. These boxes in the working become filled with the shale, and are occasionally cleared by opening the valve. The clean coal goes forward and passes into wagons, and the water drains off in a great measure at the shoot, through a perforated plate of zinc or copper, carrying with it the finest particles of dirt and coal, which are deposited in the settling pools —the purest coal being conveyed to the greatest distance.

The Papers of the North of England Institute of Mining Engineers shew an early attempt at coal washing made by Mr. Morrison on the above principle. Mr. Gilroy, of Wigan, claims to have improved upon Mr. Morrison's plan; and I have taken the liberty of quoting from Mr. Gilroy's description, as the members of this Institute who visited the Wigan district saw this very apparatus at work, and it appeared to be as good an example of spout or trough washing as could be met with in that district; the operation is merely mechanical, and has been of the greatest importance to the Northern coal-owners, in enabling them to make into good, valuable coke the large quantities of small and duff coals which had formerly been burnt to waste, and thereby saving a very considerable annual amount of money.

Mr. Morrison's invention is in operation at Coxhoe, in Lancashire, and is admirably adapted to the purpose in view.

The coals are raised by means of the buckets on the endless chains, and precipitated into the bucket; when the agitators force through the mass of coals a stream of water sufficient to precipitate the coals (by reason of their lightness, and their near approach to the same specific gravity as water) over the spout into the wagon; whilst the pyrites and the heavier articles sink to the bottom, and are let off by a valve for that purpose.

The cost of washing a ton of coals is about three halfpence.

The percentage of loss depends on the purity or otherwise of the coals and on their size. *Duff*, for example, of the Hutton seam loses about 22 per cent.; *pea* small and duff 18, and rough small about 14 per cent.

Another very simple mode of washing the impurities out of small coals, which has only recently come into operation, is at work at South Tyne Colliery, Haltwhistle, under the direction of Mr. John Rutherford.

The apparatus consists of an arrangement of boxes or troughs, into the upper series of which the water for washing is conducted by a pipe. At the end of the upper trough is a small screen, formed of $\frac{3}{8}$-inch round iron rod, placed about $\frac{1}{8}$ of an inch apart; and immediately below the screen another series of troughs are placed in a sloping position, like the screen in the upper series.

The upper troughs are 2 feet 4 inches wide and 13 inches deep; the lower ones are 2 feet 5 inches wide and 6 inches deep.

At intervals are grooves, into which slips of wood are placed one above another, at different stages of the washing; these partially check the current of water, and assist in collecting the stones and pyrites, &c. The coal is brought to the washer in the ordinary coal wagon.

It should be observed that the pipe must be bent so that the water passes *against* the end of the trough; as this is found to act better than when in the contrary direction. The mode of working will, we think, be apparent. A boy shovels the coal into the trough, and a man with a rake spreads it and keeps it under the action of the current.

The water that passes through the screen carries a good deal of smaller coal with it.

This induced us to erect the lower series of troughs, along which it is conducted, and finally passed over the perforated zinc plate.

The velocity of the current is regulated when required by raising or lowering the troughs, their arrangement being such that this is very easily effected. At present the difference of level between the pipe and the screen is about 2 feet.

With this apparatus a man and a boy can wash three wagons of coal per hour. Previous to adopting this improved apparatus, the washing was done in a rough trough about 25 feet long.

The apparatus at the Ince Hall Colliery (Plate 7) consists of a line of spouts attached at one end to the slack or duff hopper of the nut-screening apparatus, and is continued to each row of coke ovens, or if necessary to each oven.

By means of valves worked by the attendant, who is stationed near the coke ovens, water and slack are admitted, together or separately as required, into the spouts at the end attached to the nut-screen. The slack is conveyed to the coke-ovens by water, any pyrites, earthy matter, or other impurities, being deposited at the bottom of the spout whilst in transit.

The distance from the screens to the ovens is about 600 feet.

The spouts are arranged as follows:—From the screen to a point 275 feet the spout is 10 in. × 10 in. inside, with a fall towards the ovens of one in eighteen; then for 40 feet it was 10 in. × 10 in. inside, falling one in twenty-four; then 70 feet, 23 inches broad and 10 inches high, falling one in twenty-four.

The spouts are supported by single upright poles, about 60 feet apart, the centre of each being held up to the level line by wire-rope suspenders or guys reaching from pole to pole. And at a point 326 feet from the slack screen there is a valve which, when opened, and the slack being previously shut off at the screen, allows all the dirt and refuse that may be deposited in the spout down to this point to pass into the dirt wagon beneath.

Fifteen feet further there is a dam, consisting of a piece of wood 3 inches deep, which arrests the progress of any of the lighter particles of dirt which do not settle higher up the spout. When the first portion of the dam of 3 inches high is filled with dirt, another piece of wood of the same thickness is added, and so soon as the refuse accumulates behind it to the level of the top, a valve is opened and the dirt falls into the dirt-wagon, after which one of the pieces of wood before mentioned is again inserted.

Again, at a point 24 feet down, a dam is formed by another loose piece of wood, which secures any stray pieces of dirt that may have escaped the obstructions higher up; and 31 feet nearer the ovens, another loose dam, $2\frac{1}{2}$ inches high, is placed, where there is a valve to let out the dirt from both.

The quantity of ashy mine-slack washed daily is 120 tons, yielding about 6 per cent. refuse.

The water required is about eighty to ninety gallons per minute.

The attendance to the washing department costs three shillings a day, or three-tenths of a penny per ton on the slack.

The advantages of this mode of washing small coal are these—

1. Simplicity of arrangement;
2. Economy in first outlay and in cost of working and upholding;
3. Efficiency.

First, then, as to its simplicity. It will be seen that the first requisite is a copious supply of water; the spouts, dams, and valves are simple in design and not difficult to keep in order. If the distance the slack was floated could be doubled, it would no doubt be an advantage, seeing that the separation of the heavier and soluble parts of the earthy matter from the coal would be more complete, even with fewer dams than are employed in this case.

Secondly, its economy. There is also a considerable saving in the carriage of the slack by water as compared with the ordinary modes of transit. In this case the difference in favour of water is great.

As to its efficiency, the cleansing of the coal is complete, without the least possible loss of coal amongst the refuse, and the quality of the coke is greatly improved.

In one instance of trough-washing in Wales on the above principle, the length of trough is only 240 feet over which the coal passes. There are 70 tons per day washed, from which about 8 per cent. of shale is removed.

The cost in labour is—

	PER DAY.	
	s.	*d.*
3 women at 1*s.* 2*d.* per day	3	6
1 man for 2 days per week at 3*s.* per day = 6*s.*	1	0
Total, or per day	4	6

which, divided by 70 tons, is equal to about $\frac{3}{4}d.$ per ton on the coal.

The above process does not of course take out the whole of the impurities.

Machine-washing effects this much more perfectly.

The water required for washing the coal in the above statement does not require to be pumped, else the cost might be more.

Washing coal by machinery has, however, been adopted, and it is generally thought to give better results, in separating the impurities more perfectly. A machine very much after the Belgian principle, made by Mr. Sheppard, of Bridgend (Plates 8, 9, 10, 11,) may be seen in operation at the Llynvi, Tondu, and Ogmore Coal and Iron Company's Works at Maesteg, near Bridgend. The coal to be washed is delivered into a hopper, from whence it is passed through a pair of rolls, and is then elevated to a screen by

which the fine or dust coal is removed, and the remainder is screened into three sizes, each size falling into a separate compartment, where it is washed by itself.

It is very important that the coal should be washed as soon as possible after being raised, as the coal dust when newly raised is nearly all pure coal; the shales come out in small cubes, or flakes, which will not pass through the fine wire that allows the dust to escape; but if the coal is kept long exposed to atmospheric influences the shales will decompose and a good deal of them reduce to a powder, and some portions be dissolved, whereas, when fresh wrought, the short time for which it is subjected to the washing is not enough to dissolve these shales, and consequently they are passed off with the pyrites and harder substances. After washing, the coal is passed into a trough where the water is drained off, and the coal is discharged into a wagon or hopper. At the Llynvi Works the foul water flows into a settling pond, to allow the fine coal to subside; the water is then returned to the machine by a centrifugal pump, and is used over again. In the latest arrangement of the same machine the settling ponds are dispensed with, a chamber is added to the machine for that purpose, and from it the water is returned for use without the aid of a pump of any kind. The washed coal is elevated from this chamber by an elevator which has perforated buckets, and these allow the water to drain out and run back into the machine, while the coal is discharged into the wagon or hopper. Consequently there is no discharge of foul water, and a very small quantity of water is required; just enough to compensate for that which will not drain off, so as to keep the machine in action.

This arrangement removes one of the greatest objections to the use of coal-washing machines: there is no discharge of foul water; there can be no polluting of streams in consequence; and as the consumption of water is so small, coal washing can be effected in places where, under the old methods, it would not be practicable for want of an adequate supply.

After the screening and separation of the coal into various sizes, the sluice-valves through which the rubbish passes can be better regulated, so that the orifice in each valve will allow it to pass out and not the coal, as would be the case if small coal and large rubbish were in the same box. The quantity of slag or shale removed varies considerably, depending of course upon the amount mixed with the small coal. Fourteen per cent. has been removed by this process, whilst the quantity of small coal which passed away with the shale was very small, and in examining these particles it was found that they had generally pieces of pyrites attached to them. The quantity of small coal carried off by the water and collected in the settling ponds varies from 5 per cent. to 8 per cent. of the total quantity passed through the machine, and there is no difficulty in working the water over and over again after it has passed the settling ponds. A steam water-lift was found to clear the sump better than a centrifugal pump.

The machine above mentioned is capable of washing 200 tons per day of 10 hours.

It has been found from experience that the smaller the coal the more dense the coke made from it, and thus it became desirable to attach crushing rollers. In the case above mentioned these are set to a $\frac{3}{4}$-inch gauge, through which all the coal passes. It may be desirable to crush some coals finer than others; but as the rollers determine the quantity of coal passed through the machine and the regulation of the proper quantity of coal for each bosh, the $\frac{3}{4}$-inch gauge answers the purpose in the above instance.

A jigging screen has also been attached for the purpose of separating the coal suitable for each bosh; the water required for the separation of the shale from each class of coal can be thus easily regulated.

The classes into which the coals are separated are "Nuts," "Seconds," and "Small." The very fine dust is passed over without washing; for in experience it was found that whilst

working without screens, the small dust had to go into the boshes with the rest of the coal, and was carried off with the water to the settling ponds. These were filled, therefore, with small coal much more rapidly than when the screens were used and the dust passed over unwashed.

COST OF WORK.

	PER WEEK. £	s.	d.
One engine-man in charge of the whole, at 4*s.* 8*d.* .	1	8	0
Two men for discharging trucks and wagons into bunker, at 3*s.* 6*d.*	2	2	0
One labourer with rubbish and small coal trucks, at 2*s.* 8*d.*		16	0
One boy at boshes and feed, at 1*s.* 9*d.* . . .		9	6
One boy feeding crushing rolls, at 1*s.* 2*d.* . .		7	0
One man clearing small out of ponds (piece-work), say at 3*s.*		18	0
	£6	0	6

The coal used in driving the engine is about :

One ton per day, say 6 tons at 5*s.*	1	10	0
Stores, such as oils, straps, gauze wire, &c., for 1,000 tons per week	3	0	0
	£10	10	6

or a trifle over 2½*d.* per ton. This cost does not include the labour employed in putting the small coal to stock, or taking it from the stocked coal, if such has been found necessary.

FIVE SAMPLES OF COAL FROM THE SEVEN-FEET SEAM, DUFFRYN PIT, MAESTEG.

ANALYSES	Large	Nuts washed	Peas washed	Small washed	Dust unwashed
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Carbon, fixed . . .	74·144	72·960	73·696	76·930	71·312
Ash	4·440	5·380	2·560	3·840	6·040
Sulphur . . .	·766	·760	·944	·930	·848
Volatile Hydrocarbons .	19·800	20·000	22·000	18·300	21·800
Moisture . . .	·850	·900	·800	—	—
	100·000	100·000	100·000	100·000	100·000
Coke	79·350	79·100	77·200	81·700	78·200

There is a manifest benefit in using the water over again; and the results of some tests made during the working of an improved Morrison's machine, which, however, at that time did not work the water over again, are given below; and, as they show how much water was consumed, it may be instructive on this point, as well as in other respects perhaps more important.

1st Test.

6,214 gallons of water passed through catch-pond per hour; each gallon carried away 103·3 grains of coal = 92·1 lb. per hour.

The machine worked 10 hours per day and washed 200 tons of coal.

Coal carried away = 921 lb. per day, or ·21 per cent. of coal washed.

The coal carried away in the water contained 25·91 per cent. of ash.

The coal left in catch-pool contained 10·13 per cent. of ash.

280 gallons of water were required to wash one ton of coal.

2ND TEST.

6,629 gallons of water passed through catch-pond per hour; each gallon carried away 632·9 grains of coal = 599·3 lb. per hour.

The machine worked 10 hours per day and washed 200 tons of coal.

Coal carried away 5,993 lb. per day, or 1·34 per cent. of coal washed.

The coal carried away in the water contained 23·44 per cent. of ash.

The coal left in the catch-pool contained 10·67 per cent. of ash.

3RD TEST.

5,611 gallons of water passed through catch-pond per hour; each gallon carried away 636 grains of coal = 510 lb. per hour.

The machine worked 10 hours per day, and washed 200 tons of coal.

Coal carried away = 5,100 lb. per day, or 1·16 per cent. of coal washed.

The coal carried away in the water contained 29·18 per cent. of ash. A man was raising the sediment from the catch-pond, which was nearly full during the time the water was collected.

From Oct. 17 to Nov. 19, both days inclusive, washed coal delivered from washing-machine amounted to 3,577 tons; cost of labour during same period amounted to £29. 1*s.* 5*d.*

	Cost per ton.
Wages £29. 1*s.* 5*d.* ÷ 3,577 tons of washed coal =	1·95
Stores for month, say £2. 10*s.*	·17
Capital, interest, and depreciation = £6. 13*s.* 4*d.* per month	·44
Steam for 30 days, through and through coal, at 1 ton per day, and 4*s.* 6*d.* per ton = £6. 15*s.* .	·45
	3·01
Upon each 100 tons lost by washing 9 tons at 4*s.* per ton = 36*s.*	4·75
Per ton of washed coal .	7·76

The working during one calendar month showed that 297 tons of rubbish had been extracted, and that the percentages were as follow :—

	Per cent.
Washed coal delivered from machine to coke ovens	90·7
Rubbish delivered to heap	7·5
Carried away by water	1·8
	100·0

Analyses of coke made :—

No. 1 from small coal delivered as from pit not washed.
No. 2 from small coal moderately washed.
No. 3 from small coal well washed.

	No. 1. Per cent.	No. 2. Per cent.	No. 3. Per cent.
Fixed Carbon	71·55	84·37	91·82
Volatile Matter	3·53	2·88	·04
Ash	23·21	11·48	7·45
Sulphur	1·15	·71	·55
Water	·56	·56	·14
	100·00	100·00	100·00

In each case the coal was coked for 48 hours, and in similar ovens.

TABLE A.

SHOWING THE RELATIVE PROPORTIONS OF SHALE ETC. TO COAL, AND SHALE TO COKE.

Percentage of shale to coal	Percentage of coal to shale	Coke produced, allowing 30 cwt. of coal to 1 ton of coke	Percentage of shale to coke
5·0	95·0	63·34	7·89
7·5	92·5	61·67	12·16
10·0	90·0	60·00	16·66
12·5	87·5	58·33	21·36
15·0	85·0	56·67	26·52
17·5	82·5	55·00	31·52
20·0	80·0	53·34	37·59
22·5	77·5	51·67	48·03
25·0	75·0	50·00	50·00

An extract from "Proceedings of the North of England Institute," Vol. XII., page 38, shows a comparison in weight between coke made from washed and unwashed coals, as ascertained from the loading of ten large wagons of each description, at Framwellgate Colliery :—

	Coke from washed coals.	From unwashed coals.
1.	73 cwt.	75 cwt.
2.	71 „	76 „
3.	69 „	81 „
4.	70 „	75 „
5.	73 „	80 „
6.	75 „	87 „
7.	66 „	72 „
8.	74 „	73 „
9.	72 „	73 „
10.	77 „	73 „
	720 cwt., or 36 tons.	765 cwt., or 38 tons 5 cwt.

Showing the coke made from the washed coals, bulk for bulk, with that made from the unwashed coals, to be 6·25 per cent. lighter.

As the comparative weight of coke from washed coals is now rather an important question, owing to its increasing manufacture and export, and from the frequent disputes arising with ship-owners as to its weight, it would be desirable that further and more accurate experiments be made to determine the point.

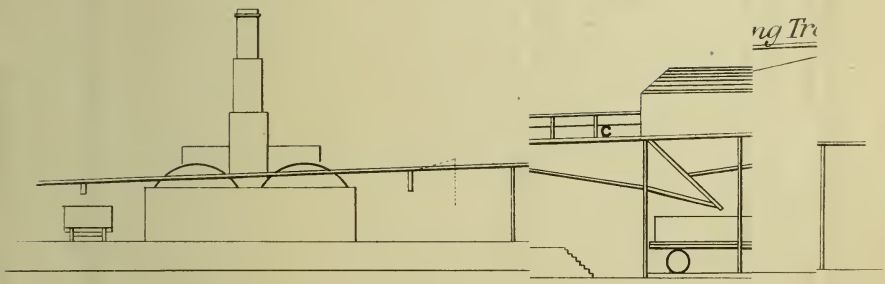
But the effect of crushing and washing the coal is generally found to make the coke more dense, and if watered in the oven before it is drawn, will show a uniformity and strength that the unwashed coal will not. It is less wasteful in carriage, and, if exported, by far more economical than coke made from unwashed coal, therefore worth more in value.

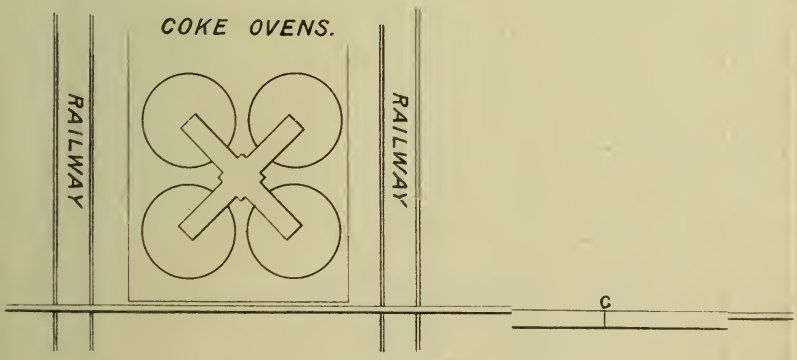
The question of washing coal has been here treated as being applicable to the coking coals only. There is no reason why it should not be applied to clean the large amount of small steam-coal now stored away and lost underground, so soon as the market value of coal will enable the colliery proprietor to carry out with a profit.

The cost of working is now before the Members, to which they must add the loss in the percentage of the rubbish they find in their respective coal, which will enable them to estimate if a profitable market can be found for the product, either by converting it into Patent Fuel, or by converting it for use into gaseous products at the works.

Plates 12 and 13 represent Mr. Sheppard's new machine for washing breeze and ashes; the principle being the same as in the coal washing machine already described.

The clean breeze, at each stroke of the plunger, is carried on to a perforated plate, through which the water returns to a chamber underneath, and from thence passes through a valve to the body of the machine, to be again forced through the ashes; so that a continuous circulation of the same water takes place. The clinker, as it accumulates, is removed through a sluice in the same manner as the shale from the coal washing machine. A screw carries it to the side of the machine, whence it is lifted by an elevator, which has perforated buckets to allow the water to drain back again into the machine.





(Proceedings S. W. Inst. Engs. 1877 No. 3 Vol. 10)

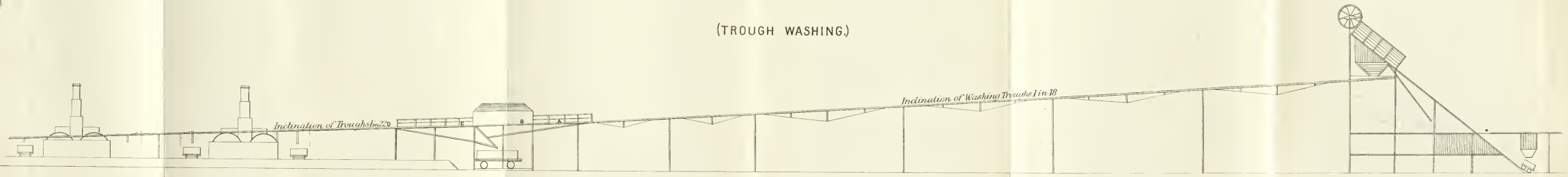
PLAN &c. OF COAL WASHING APPARATUS AT INCE HALL COLLIERY

Illustrating Mr. James Brogden's Paper

on

COAL WASHING.

(TROUGH WASHING.)



ELEVATION.

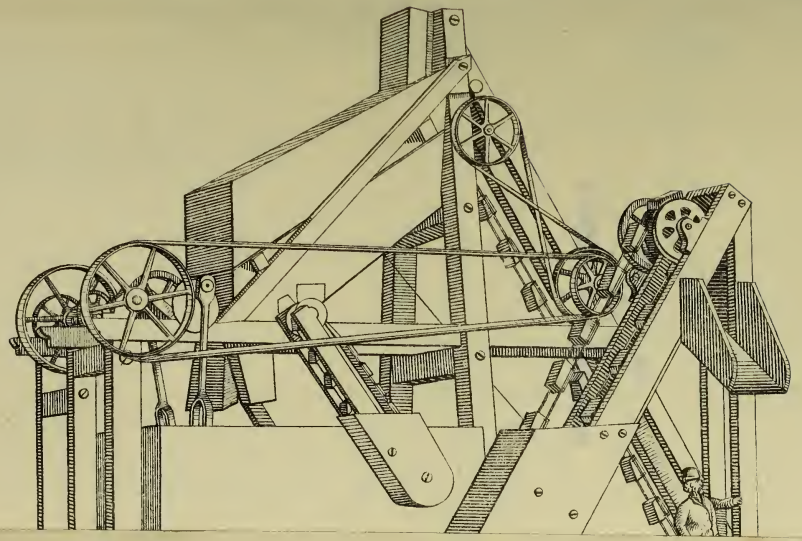
PLAN.

SHEPPARD'S PATENT COAL WASHING MACHINE

Illustrating Mr. James Brogden's Paper

on

COAL WASHING.

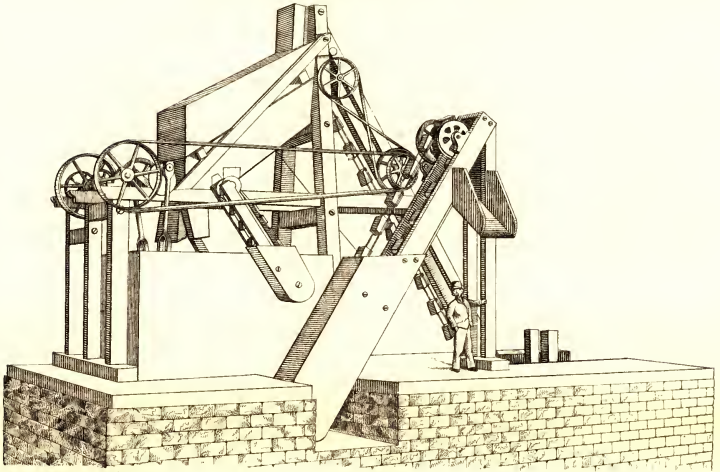


SHEPPARD'S PATENT COAL WASHING MACHINE

Illustrating Mr. James Brogden's Paper

on

COAL WASHING.



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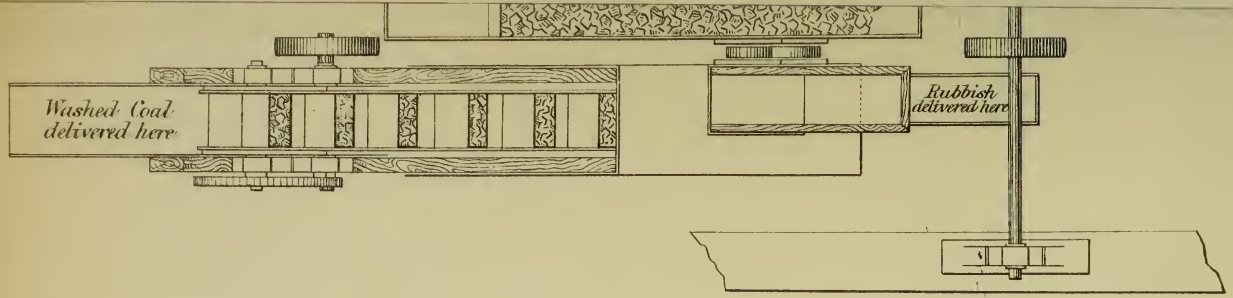


GROUND PLAN

(Proceedings S.W. Inst. Engs. 1877) N 3 Vol 10.

A. Reid, Newcastle on Tyne

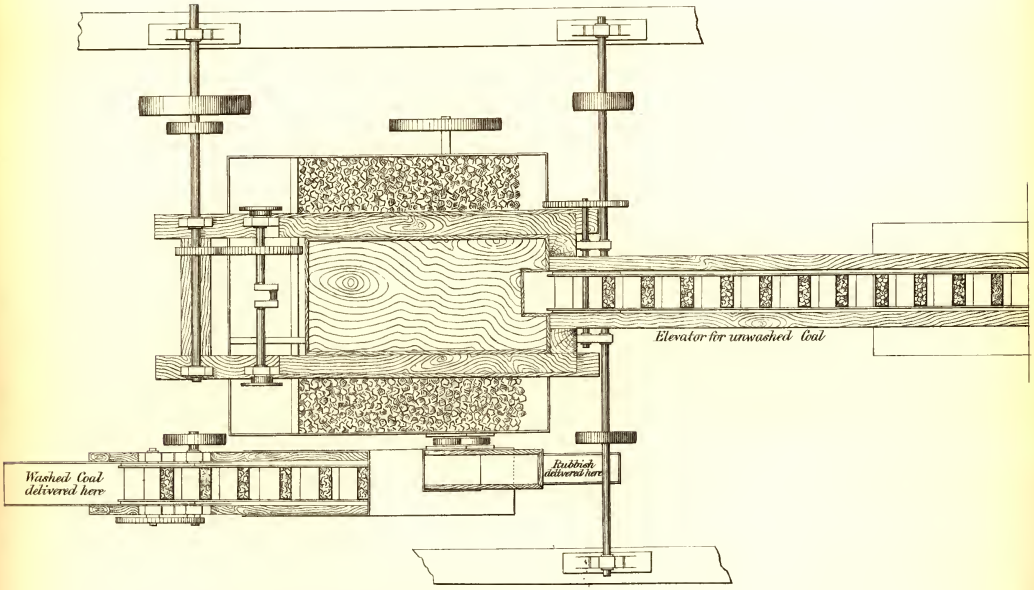
SHEPPARD'S PATENT COAL WASHING MACHINE

Illustrating Mr. James Brogden's Paper

on

COAL WASHING.

Scale ¼ Inch to one Foot.



GROUND PLAN

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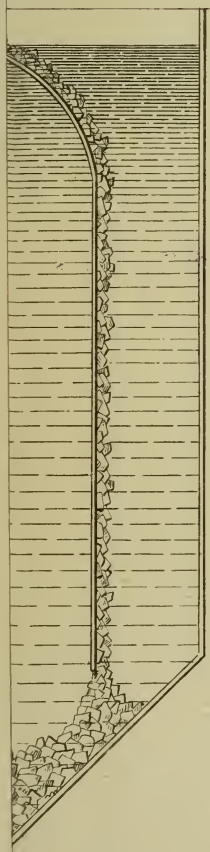

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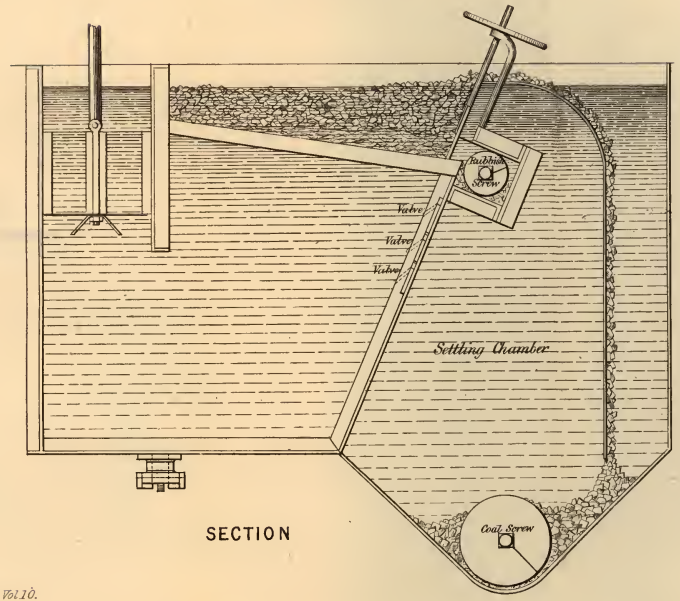
SHEPPARD'S PATENT COAL WASHING MACHINE

Illustrating Mr. James Brogden's Paper

on

COAL WASHING.

Scale ½ Inch to one Foot.



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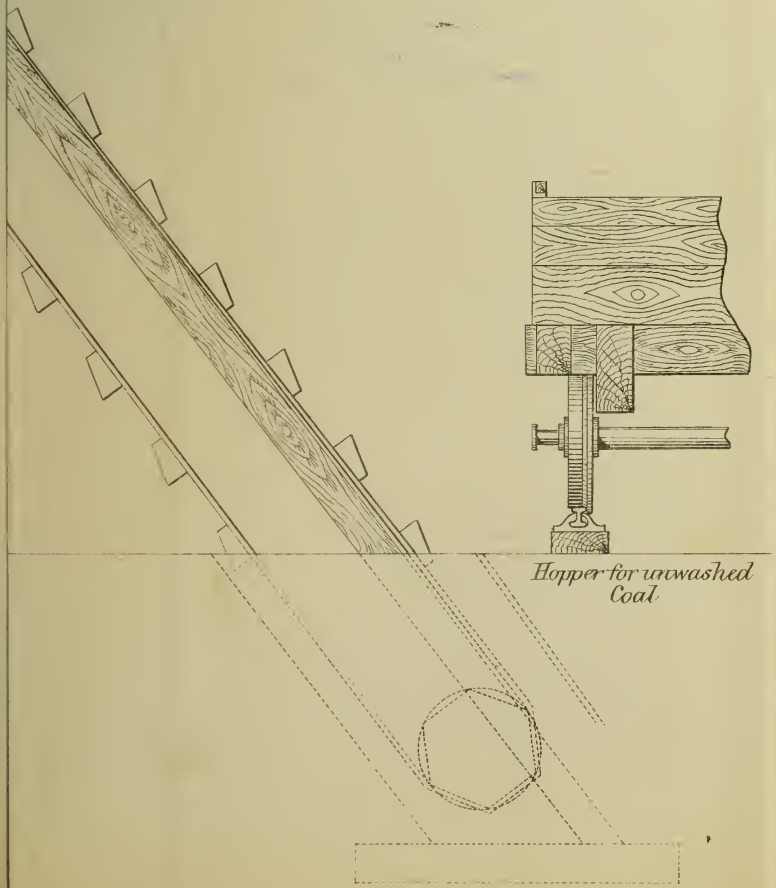


Hopper for unwashed Coal

A. Reid Newcastle on Tyne.

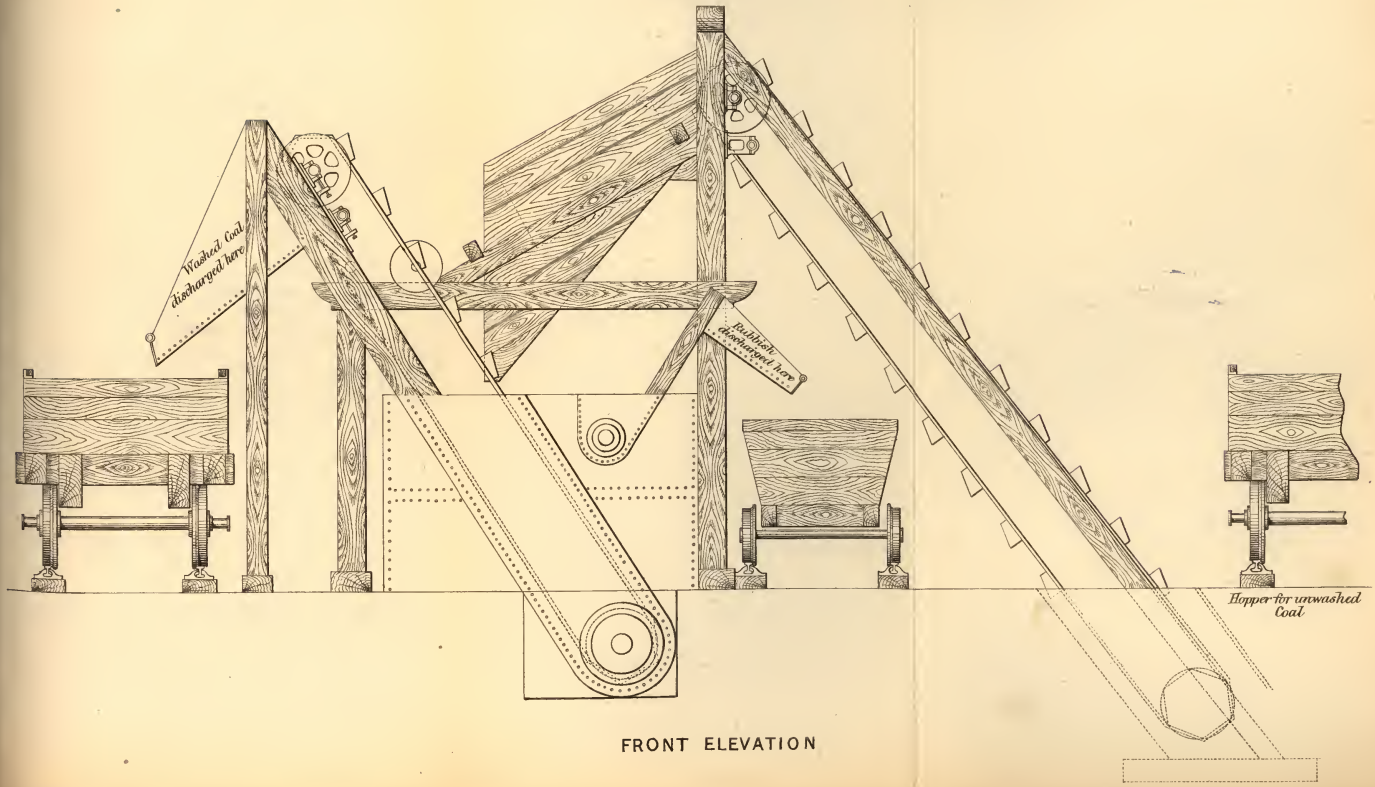
SHEPPARD'S PATENT COAL WASHING MACHINE

Illustrating Mr James Brogden's Paper

on

COAL WASHING.

Scale ¼ Inch to one foot.



FRONT ELEVATION

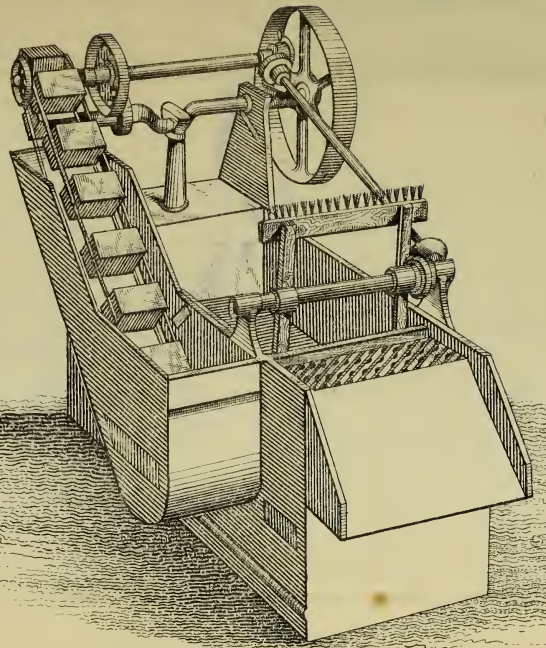
A. Reid, Newcastle on Tyne.

SHEPPARD'S PATENT BREEZE WASHING MACHINE

Illustrating Mr. James Brogden's Paper

on

COAL WASHING.



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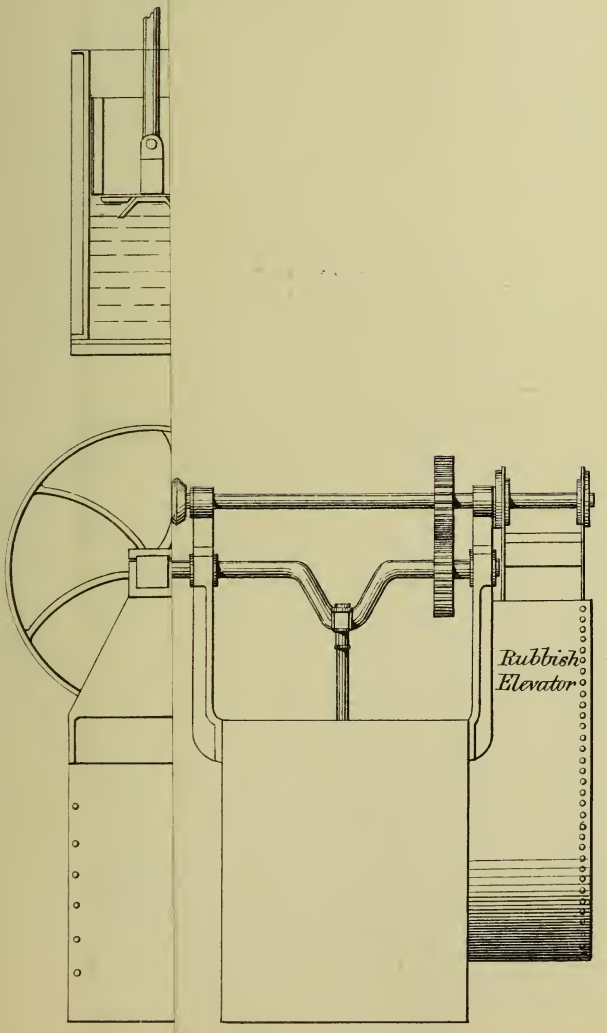

END ELEVATION

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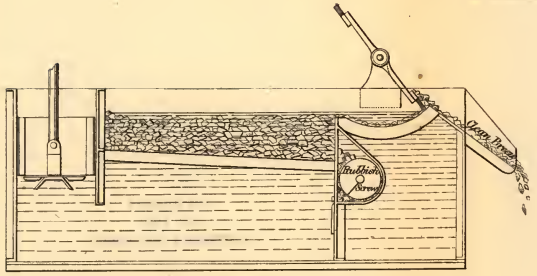
SHEPPARD'S PATENT BREEZE WASHING MACHINE

Illustrating Mr. James Brogden's Paper

on

COAL WASHING.

Scale ½ Inch to one Foot.



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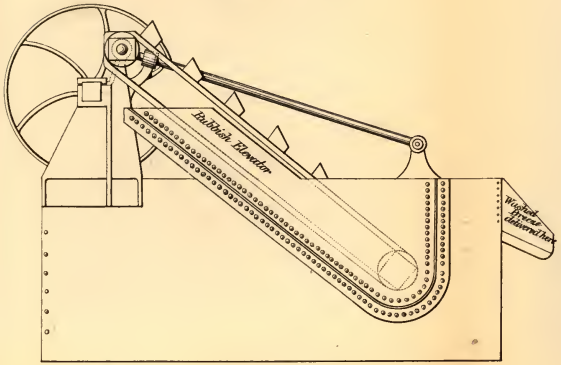
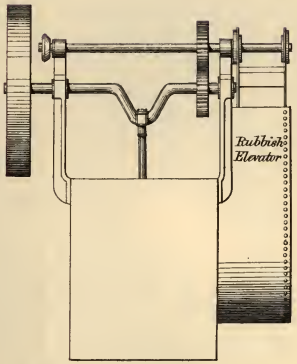


SIDE ELEVATION



END ELEVATION

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PLAN OF RESERVOIR

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A Reid, Newcastle on Tyne

PLAN OF RESERVOIR

Accompanying Mr George John Jee's Paper

on

THE CWM CARNE RESERVOIR.

Scale _ 12 Chains to an Inch

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A.Reid Newcastle on Tyne

The clean breeze, when deposited on the perforated plate, at each stroke of the plunger, is cleared away by brushes, so arranged that the breeze deposited by one stroke of the plunger is cleared by a brush before another lot is forced forward by the succeeding stroke; so that the perforated plate is thus always open for the water to drain quickly away. The quantity of water required to work it is very small, and the power required to work the machine with screen and elevator is said to be about 3 to 4 H.P.

ON

THE CWM CARNE RESERVOIR.

By Mr. George John Jee.

The Cwm Carne Reservoir, commonly known as "Rogers' Pond," was situated in a deep and narrow lateral valley, or dingle, which branched off from the Ebbw Valley, in an easterly direction, near the village of Abercarne, in Monmouthshire, and which extended for a considerable distance between the neighbouring hills, to its termination near the southern base of the Mynyddmaen range, about three and a half miles to the north-east of Abercarne.

The Carne Valley was surrounded on all sides by lofty and precipitous hills, the most commanding eminence on the range, that forms the southern boundary of the valley, being called "Twyn Barlwm," which was the well-known site of an ancient Roman encampment.

The position of the Reservoir was about one-third of a mile from the junction of the Carne Valley (Cwm Carne) with the Ebbw Valley, and the distance from the junction of the two valleys to Newport was about nine miles. (See Plan, Plate 14.)

The Cwm Carne brook flowed through the Carne Valley, and formerly supplied the Cwm Carne Reservoir, and where the Carne Valley opened out into the Ebbw Valley, the turnpike road leading from Crumlin to Newport was carried over the brook by an embankment about 30 feet high, and a large arch carried the water under the road embankment at that spot.

On the eastern side of the road, between it and the Re-

servoir, a hollow, or "cul de sac," was formed by the embankment of the road crossing the narrow outlet of the valley, and in the hollow that was so formed were some cottages: one small detached cottage being entirely below the level of the road, and a row of three or four other cottages partially so.

Within a short distance of the road, and nearly parallel with it, but lower down the valley, the Western Valleys Branch of the Monmouthshire Canal also crossed the outlet of the Carne Valley, being carried over it on an embankment supported with side walls of masonry of considerable thickness and strength, a large arch having been formed under the canal to carry off the water from the Cwm Carne brook.

Below the canal, the valley opened out upon a comparatively level piece of land, which extended down to the Ebbw river.

The Cwm Carne Reservoir was probably one of the oldest constructions of the kind in that part of the country, the date of the Monmouthshire Canal Act being *tricesimo secundo* George III., A.D. 1792, and it was probable that the Reservoir, which was used for supplying the Canal with water, was constructed not very long after that date.

For many years before the accident, however, the Reservoir appears to have been little used, and was suffered to fall into comparative neglect and disrepair.

On Wednesday, the 14th of July 1875, which will be long remembered as the date of the great floods in Monmouthshire and South Wales, it commenced raining early in the day, and continued without intermission and with increasing violence until some time early on Thursday morning, when it gradually ceased; the rainfall had been particularly heavy, and continuous from mid-day on Wednesday until some time early on Thursday morning.

In consequence of such an unusual rainfall, much damage was caused in different places throughout the district, more especially where proper and efficient means of safety had not been provided to meet such an exceptional occurrence.

From the statement of persons living in the neighbourhood of Cwm Carne, it appeared that considerable apprehension was felt with regard to the safety of the Reservoir, owing to the well-known defective state of the embankment, and the correctness of such suspicions was only too fully and fatally confirmed by the lamentable accident that occurred.

The earliest account of the state of the Reservoir on the day of the accident was given at the inquest which was held on those who were drowned. A witness who passed the Reservoir at about 2 P.M., stated that at that time it was very full, but that the water was not then running over the embankment. The same witness also mentioned that he then saw the person who attended to the Reservoir, and supposed that he was opening the sluices, as he had the necessary appliances with him for the purpose.

It does not appear, however, that any extra precautions were taken on the day of the accident to watch the state of the Reservoir, as after opening the two upper sluices, which were used for letting off the flood water, at about 2 P.M., the person who attended to the sluices left the place, and did not again return. It should, however, be mentioned that that person had other important duties to perform in connection with the locks and canal, which took up the principal portion of his time, and he must consequently be exonerated from any neglect of duty in not stopping at the Reservoir.

From the evidence of the witnesses who were examined at the inquest, the water was first seen flowing over the top of the embankment of the Reservoir at about half-past 5 P.M. on the day of the accident, and the depth of the overflow was then estimated at about 3 inches. About half an hour later it was also seen by another person, who stated that the water was flowing over the top to a depth of about 3 inches, and for a width of some 15 feet in the centre of the embankment. Again, at 7 o'clock, the water was seen by another witness running over the centre of the embankment for a distance

of about 70 yards, and to a depth of about 4 inches; and another person, who attempted to cross the embankment at the lower end of the Reservoir at about twenty-five minutes past 10 P.M., stated that the water was then overflowing to a depth of from 6 to 9 inches, and that he was obliged, in consequence, to go round by another way.

From the evidence of the different witnesses who were examined at the inquest, it may therefore be safely concluded that the water must have commenced flowing over the centre of the embankment on the day of the accident some time between 4 and 5 P.M., or possibly somewhat earlier, and it must be apparent that the Reservoir was in a very alarming and dangerous condition early in the afternoon of that day; it was therefore most unfortunate that no one appeared to have realised the immediate and pressing danger, or to have taken any measures to prevent the unfortunate catastrophe and loss of life which subsequently occurred.

So far as could be ascertained from the evidence, the water continued to flow over, in a continually increasing stream, until, at about 11 P.M., it washed away the covering of turf on the top of the centre of the embankment; and soon afterwards the increasing rush of water quickly cut a chasm through the body of the embankment, which consisted of materials that would be readily washed away; and the whole of the water in the Reservoir rushed out with terrific violence in a very short space of time, cutting down the embankment in a wide and deep chasm extending to the bottom.

Immediately the embankment gave way, the water rushed with irresistible force through the narrow dingle below the Reservoir, down towards the outlet of the valley; its course being plainly shown by the shattered and bark-stripped trees and immense accumulation of *débris* that covered the ground.

When that immense body of water reached the lower portion of the valley, where it was crossed by the turnpike road, the archway under the road embankment was, of course, quite

inadequate to carry off the enormous volume of water, which consequently became "ponded back," and quickly accumulated until it reached the level of the road. In this way the small cottage, previously described, was quickly submerged, and the three inmates drowned without having had any chance of escape.

The row of workmen's cottages, previously referred to, was also partly submerged, and one man made his escape and rescued his family by making a hole through the back wall of the cottage in which he lived, the ground at the back being on a somewhat higher level, and having a slope towards the back of the cottages. Another of the inmates who lived in the same row of cottages after placing his wife in the safest position that he could find, took to the water, which was several feet deep in the bedroom of the house, and swam to land from one of the bedroom windows. That circumstance was mentioned with the object of showing that for some time the water must have been "ponded up" in the lower end of the dingle against the turnpike-road embankment, and that at that time the water was comparatively tranquil, which enabled the man to escape by swimming to land.

In a comparatively short space of time, however, the water entirely filled up the whole of the hollow above the turnpike-road embankment, to the depth of about 40 feet, and then overflowed into the hollow space between the road embankment and that of the canal, soon cutting a breach through the road embankment about 40 yards in width; and when this occurred, the submerged cottage and its drowned occupants were doubtless swept away. After filling up the hollow space between the turnpike-road embankment and that of the canal, the water found its way over the top of the canal embankment, in consequence of the arch under the canal being of insufficient capacity to carry off such an immense accumulation of water.

As soon as the water overflowed the canal embankment it produced very much the same effect as it had on the embankment of the turnpike road; for, in a few minutes, a chasm about

35 feet in width was suddenly washed away, and the water, having no further obstruction to its course, rushed down, together with the liberated water from the canal, with irresistible force over the level space below the canal into the Ebbw river, which met the Cwm Carne brook at that spot.

The sudden influx of such a great body of water into the River Ebbw, already greatly swollen by many hours' heavy and continuous rain, caused the banks of that river to be inundated on both sides for several miles, and occasioned much damage to property in its course.

A substantially built dwelling-house and premises, occupied by the late Mr. John Hunt and his family, had been erected by him about three years previously on the level piece of ground between the canal and the river, and adjoining to and connected with it was a much older building in his occupation, used for many years as a flannel factory. The dwelling-house was at once completely swept away by the descending torrent, and all the eight inmates drowned, with the exception of the late Mr. Hunt himself, who happened to be washed into a tree on the banks of the Ebbw river, from whence he was rescued, but did not long survive. The flannel factory, which was a much older building, withstood the shock; but it was completely wrecked, and also partially buried in a large accumulation of earth and stones. Two of the late Mr. Hunt's apprentice boys occupied a room in the last-mentioned building, and one of them was swept out of the place and carried away by the flood; the other, however, managed to save himself by clinging to a warping machine, which was attached to a beam in the building.

The foregoing circumstantial account of the occurrence has been compiled from a careful examination of the best information that could be obtained; but the actual facts cannot be positively determined in all their detail, as the catastrophe occurred about 11 P.M. on an exceedingly dark and tempestuous night, when it would have been impossible to make any careful or exact observation of what took place.

Having given the foregoing sketch of the accident, it will now be desirable to describe the conditions which appear to have brought about such a lamentable loss of life and destruction of property.

The length of the Cwm Carne Reservoir (*see* Plan, Plate 14) was about 18 chains, or 400 yards, and the extreme width, near the lower end, was about 419 feet. The Reservoir was formed by throwing a very high embankment across a narrow portion of the valley, which bayed back the water in the form of an isosceles triangle, broadest at the lower, or embankment end, and gradually becoming narrower towards the top, where the water flowed in.

Assuming the above measurements to be approximately correct, the area of the Reservoir was about 32,000 square yards, or about 6½ acres, which agreed pretty nearly with the generally accepted measurement of about seven acres.

The extreme depth of water opposite the centre of the embankment at the lower end was about 35 feet 6 inches (35·69), the measurement being taken from the top of the sill of the waste-water weir. (*See* Longitudinal Section, Plate 15.) It would be very difficult to give even an approximate measurement of the average, or mean depth of the water, as its bed was very irregular, and the mean depth could only be satisfactorily ascertained by taking a series of sections, which was not done.

The actual quantity of water which the Reservoir contained cannot, therefore, be accurately stated; but assuming an average depth of 10 feet, and taking the weight to be 1,200 tons per acre for each foot in depth, there would be 12,000 tons of water per acre, which, multiplied by a total area of, say, six and a half acres, would give 78,000 tons; but at the time of the accident the mean depth would, no doubt, be considerably more, and in all probability the Reservoir at that time contained over 90,000 tons of water.

The total pressure of the water on the face of the embankment cannot be accurately determined without a careful measurement of the area of the face of the embankment; but taking the length

of the bay embankment to be 419 feet, and the mean depth at 24 feet, it would give a total vertical area of 10,056 superficial feet, and a total pressure on the entire area of the embankment of 3,367 tons.

In the foregoing figures no calculation has been made for the wind acting on the surface of the water, which, when blowing strongly from the east, would have a very powerful effect in pressing the water from the head of the Reservoir towards the lower end; and the evidence which was given at the inquest went to prove that the wind was blowing strongly from that direction on the night of the accident.

It would, of course, be impossible to make any calculation, based on reliable data, with regard to the effect produced by the wind on that night, but it should always be taken into account and provided for, where large artificial accumulations of water are dammed up in exposed situations.

The width of the embankment of the Cwm Carne Reservoir where the water broke through is about 22 feet, and on the north side about 19 feet, and it gradually becomes wider from the centre towards the extremities, which cannot be considered an approved method of construction, as the greatest width and strength, if any difference existed, should have been in the centre, where the greatest pressure would have to be resisted. (*See* Cross Sections, Plates 16, 17.)

From careful levellings taken soon after the accident, it was ascertained that there was a gradual slope or fall from the two ends of the embankment towards the centre, where it gave way, and also a fall from the edge of the embankment next the water towards the outside edge. The height of the embankment above the waste-water weir, at the southern angle of the Reservoir, as shown by the reduced levellings, was 2·55 feet, while at the edge of the embankment next the water, on the south side of the chasm, it was only 1·31 feet, and at the outside edge of the embankment at the same spot only 0·16 feet, or less than two inches only, above the top of the sill of the waste weir. The height of the northern

extremity of the embankment, near the edge of the water, above the level of the top of the sill of the waste-water weir, was about 2·24 feet, while at the water edge on the north side of the chasm the difference in level was only 1·09 feet, and at the outer edge of the same spot 1·23 feet, thus showing a difference in level at the water edge of only about 13 inches.

As the evidence that was given at the inquest showed that the water was flowing over the centre of the embankment at 5.30 P.M. on the day of the accident, some hours before the embankment was carried away, it may be fairly assumed that the lowest portion of the embankment must have been in the centre, where it was washed away; and in all probability the edge of the bank near the centre of depression could not have been more than *a few inches* above the level of the top of the sill of the waste weir. It seems scarcely necessary to point out the dangerous condition of the embankment, as shown by those levellings, and that defect will be hereafter referred to as one of the leading causes that gave rise to the deplorable accident which occurred.

The embankment was formed of earth, and was without any facing of masonry, or protection of any other kind, with the exception of a low dry wall of stones about three feet six inches in depth at the top edge of the embankment and near the level of the surface of the water. The dry stone wall had, however, apparently been washed away in two or three places on the southern end, and not having been replaced, the wash of the water had also caused some indentations in the bank in those places.

There appeared to have been a bed of puddle in the centre of the embankment, having a width of from 8 to 10 feet towards the bottom, and gradually decreasing in thickness towards the top; but the puddle appeared to be of very inferior quality, and, judging from a trial of the portion exposed, it was not of a sufficiently plastic character to hold water without great risk of leakage. The material which was used as "puddle" in the embankment, was probably obtained near the spot, from exca-

vations during the formation of the Reservoir, being entirely different from the retentive alluvial clay of the Old Red Sandstone formation, which was used from time to time for patching up leaks in the embankment.

The Cwm Carne Reservoir being one of the oldest works of the kind in the district, was constructed, very probably, before hydraulic engineering had received the attention that had been more recently devoted to the subject. In former years it was too often the practice to construct hydraulic works (as in that instance) in a very unsubstantial and imperfect manner, and, in the construction of ponds and reservoirs, it was not unusual to throw an embankment of earth and stones across a valley in some suitable spot, constructed of the materials obtained from the excavation of the pond, and using for puddle the inferior clay, which could be obtained with the least inconvenience in the immediate locality.

In consequence of the serious accidents and destruction of property which had been caused from time to time from badly constructed works of that description, it became the practice in late years to devote much greater care and attention to the carrying out of such undertakings, and in the present day the highest and best engineering skill and experience that could be obtained were frequently employed in the superintendence and construction of such works. As an exception to the inferior work of former years, which had been very justly condemned, it was satisfactory to call attention to the very extensive ponds, or reservoirs, in the Glyn Valley, near Pontypool, which were constructed many years ago in a most substantial and scientific manner; and in that respect would bear favourable comparison with most modern works of the same kind and of the best description. The Glyn ponds, which have been disused for many years, were within a few miles of the Cwm Carne pond; and it was somewhat singular that there should have been such a marked difference in the construction of the two Reservoirs.

Although the Cwm Carne Reservoir stood for a great number

of years—probably nearly a century—it was not constructed on safe and approved principles, more especially having regard to the great body and head of water to be retained, and the mountainous nature of the district; and it was not surprising to learn from the evidence of the witnesses at the inquest, that it had long been considered to be in a leaky and dangerous condition.

The means that were provided for the escape of the storm water were of the following description:—There was a deep culvert and sluice, apparently of considerable size, in the pond at the lower end, and nearly opposite the centre of the embankment, which, when in operation, would have drained off the water from the bottom or lowest level of the pond; but that sluice does not seem to have been in proper working order for some time, as the entrance was buried beneath a large and apparently old accumulation of mud, and it appeared that it was not accessible when the Reservoir was full of water, for the top of the shaft would then have been many feet below the surface of the water and consequently, on any emergency, it was entirely useless as a means of providing an outlet for the storm water. That important outlet should have been kept in proper repair and working order, and some means should also have been provided for raising the floodgate in any case of emergency, which might have been effected by raising the shaft, and by making a platform to communicate with the embankment.

When the Reservoir was first constructed, probably there was some means provided for raising the floodgate when the Reservoir was full, as it was scarcely probable that an important sluice of that description would have been constructed for the purpose of merely draining off the water when it had reached a low level. If that view were correct, the upper part of the shaft of the sluice probably gave way and had not been repaired; and that conclusion seemed to be confirmed by the broken and irregular state of the top of the shaft, and also by the dilapidated state of the appliances inside for discharging the water.

In consequence of the large accumulation of mud at the base of the sluice, it was not possible to measure the diameter of the outlet; but it was stated in the evidence given at the inquest that it was about 3 feet in diameter, and the depth from the surface of the water to the centre of the outlet about 32 feet.

The theoretical discharge from such an opening would be nearly 320 cubic feet per second; but to obtain the actual discharge, it would be necessary to make the proper allowance for the loss of head due to the velocity of entry, and for the friction of the water passing through the culvert, which was carried under the embankment. Assuming that the length of the culvert was about 47 yards, or 141 feet, the discharge would be reduced, after making the above deductions, to about 69,000 gallons per minute, or about 184·6 cubic feet per second; the calculated consumption of head for velocity of entry being 16·728 feet, and for friction 15·229 feet, making a total head of 31.957 feet, or, say, 32 feet.

There was also a circular stone culvert 2 feet 7 inches in diameter, about 132 feet long, carried through the embankment, at a vertical depth of 23·95 feet below the level of the sill of the waste-water weir. That sluice, or culvert, could be closed or opened by means of a floodgate, which was worked at a point on the embankment about 89 feet to the north of the waste-water weir. The theoretical discharge from an opening 2 feet 7 inches in diameter would be about 205 cubic feet per second; but after allowing for the loss of head due to velocity of entry and friction, the actual discharge would not be more than 43,245 gallons per minute, or about 115 cubic feet per second; the consumption of head for velocity of entry being 11,978 feet, and for friction 11·828 feet, making a total head of 23·806 feet, or, say, 24 feet.

There was also a third culvert and sluice, situated at a depth of 11 feet 6 inches below the edge of the waste-water weir, and having a diameter of 2 feet 5 inches; this, when fully open, would be capable

of carrying off 78·4 cubic feet per second; the theoretical discharge from the unimpeded opening being 124·4316 cubic feet per second, and the consumption of head due to friction 4·3108 feet, and for velocity of entry 7·1877 feet, making a total head of 11·4985 feet, or, say, 11 feet 6 inches.

The overflow, or waste-water weir, was situated in the south-western corner of the Reservoir, and was about 18 feet in width, and about 2 feet 6 inches in depth from the level of the surface of the embankment at that point to the top of the sill. It was paved and faced with masonry, and appeared, in that respect, to have been properly constructed. The theoretical discharge from that outlet, with a head of 12 inches, taken at a proper distance from the entrance, would be 23,973 gallons per minute; but after making the necessary allowance for the loss of head arising from friction, the actual discharge from the above opening would not exceed 18,215 gallons per minute, or 48·73 cubic feet per second. The calculation for the overflow on the waste weir has been limited to 12 inches, because that depth was the greatest head of water that could rise on the sill of the weir when commencing to overflow the top of the centre of the embankment.

The Reservoir was fed by two streams, the larger tributary being the Cwm Carne brook, and the smaller one the Cwm Gappy brook. The first-mentioned stream always contained a considerable body of water, and during a heavy rainfall it became quickly flooded, owing to the mountainous nature of the district. There was a bridge over the Cwm Carne brook, within a short distance of the upper end of the Reservoir, having an archway 7 feet 6 inches in height, and a width of 6 feet in the clear.

There was also a circular culvert 3 feet 6 inches in diameter, conveying the water of the Cwm Gappy brook under a road on the eastern side of the valley at the upper end of the Reservoir. The latter culvert was quite full, and the water partly flowing over the road on the morning following the

accident; the bridge over the Cwm Carne brook was also full up to the springing of the arch, or within 18 inches of the top, early on the same day.

Considering the great quantity of rain which had fallen, and the steep and mountainous character of the neighbourhood, it would not, perhaps, be an excessive estimate to assume that the mean velocity of the water passing through the bridge and culvert referred to was not less than eight miles per hour; such a rate not being an unusual estimate for mountain streams when very much flooded. So great a velocity would, however, only occur on special occasions, similar to that now under consideration; and it might be considered an exceptionally rapid current, being equivalent to a central surface velocity of 9·52 miles per hour.

Assuming that the quantity of water flowing into the Reservoir from those sources on Wednesday evening, some hours before the full height of the flood, was about the same as during the following morning, the quantity of water discharged into the Reservoir from the Cwm Carne brook was 422·28 cubic feet per second, and that from the Cwm Gappy brook equal to 112·85 cubic feet per second, thus making a total inflow of 535·13 cubic feet per second.

To the foregoing quantity must be added the rainfall on the surface of the Reservoir, which would amount to 3,630 cubic feet per acre per inch of rainfall; and taking the total fall of rain to have been 3·74 inches, it would amount to about 90,000 cubic feet, which, distributed over the duration of the rainfall, or, say, 18 hours, would be equivalent to an inflow of 1·39 cubic feet per second.

It will be seen, however, that the inflow of water from the last-mentioned source was quite insignificant in quantity compared with the inflow from other sources; and I have only referred to it, in order that it may not be considered an omission which should have been taken into account.

The water running into the pond from the sides of the hills immediately surrounding the pond, and not flowing into the Cwm Carne and Cwm Gappy brooks, must also be taken into consideration; but the inflow from that source would naturally be small compared with the general drainage of the very large area which forms the watershed of the two brooks which supplied the Reservoir. From the Ordnance Survey it appeared that the surface area of the surrounding lands draining directly into the Cwm Carne Reservoir (independently of the two brooks) was about 80 acres, or one-eighth of a square mile, and as the area of the watershed of the Cwm Carne and Cwm Gappy brooks was about 1,720 acres, it may perhaps be fairly assumed that the inflow of water would be in proportion to the respective areas, or, say, for the former area $\frac{1}{21.5}$ part of the estimated inflow derived from the Cwm Carne and Cwm Gappy brooks, or about 24·88 cubic feet per second. It must, however, of course, be understood that the foregoing calculations are merely intended as an approximate estimate only of the inflow of water from the various sources, giving the following results, viz. :—

Cwm Carne brook	422·28
Cwm Gappy do.	112·85
Rainfall on pond	1·39
Other surface drainage	24·88
Total cubic feet per second	561·40

It has already been seen that the maximum available means of discharge were not more than sufficient to carry off about 241·77 cubic feet per second, as follows :—

No. 1, or Upper Culvert	78·4
No. 2, or Middle do.	115·0
Waste-water Weir	48·73
Total cubic feet per second	241·77

From the foregoing estimates, based on the best available

data, it appeared that the flow of water into the Reservoir must have been altogether beyond the means which had been provided for carrying off the overflow, long before the flood had reached its highest, or most dangerous point; and that view was confirmed by the statements of the witnesses at the inquest, who asserted that the water was flowing over the embankment early in the evening of the day on which the accident occurred. In fact, it appeared that the means provided for the escape of storm water were altogether insufficient for such a purpose.

The drainage area, or watershed, supplying the Cwm Carne Reservoir, as shown by the Ordnance Survey, was about 1,800 acres, and taking one inch of rainfall as being equivalent to 3,630 cubic feet per acre, a rainfall of 3·74 inches over that area would amount to about 24,437,160 cubic feet, or about 680,000 tons.

It may be remarked that as that heavy rainfall occurred during an exceedingly wet summer, the loss of water by absorption and percolation into the ground would be comparatively small; and as the watershed consisted principally of very steep mountain slopes, the drainage would naturally be very rapid, and the loss of water by evaporation consequently considerably less than would be the case in a more level district; and it may be assumed that fully three-fourths, or 75 per cent., of the rainfall would drain off, and that the discharge from the drainage area under notice would be at least equal, if not in excess, of the above-mentioned quantity.

In reference to that subject, it is stated in Neville's well-known work on "Hydraulic Engineering," that a summer flood on the Armagh river, in the county of Galway, in 1851, yielded a discharge of 13·02 cubic feet per acre of the drainage area per minute. The area of the watershed at Cwm Carne being estimated at 1,800 acres, the discharge at the above rate, or, say, 13 cubic feet per minute per acre, would amount to 23,400 cubic

feet per minute, or 390 cubic feet per second, while the calculated discharge at Cwm Carne, amounting to 562 cubic feet per second, was somewhat greater, as might have been anticipated from the conformation of the ground, and the probable greater rainfall.

The comparative yields of different drainage areas in various districts and seasons, and from different geological formations, was a subject that had not apparently hitherto received very much attention, although it was a matter of considerable importance to the hydraulic engineer, and should receive thorough investigation. No record could be found of any rain gauge that was taken at any point nearer than Cardiff, at which place it was stated that a fall of 3·740 inches had been registered. The distance from Cwm Carne, in a direct line from Cardiff, was about 11½ miles, and as the rainfall was very general, and extended over the whole district, the above register might, in the absence of other data, be adopted as a very near approximation to the actual rainfall in the neighbourhood of Cwm Carne. At the same time, it was a well-known fact that, on ordinary occasions, the rainfall at lower levels, during a given time, always exceeds the rainfall at greater altitudes, and as the drainage area at Cwm Carne was probably several hundred feet above the position at which the rainfall was registered at Cardiff, it would be correct to infer that a diminished rainfall would result from the increased elevation.

An inspection of the following Table, which was the result of very carefully conducted experiments made at York during the years 1832, 1833, and 1834, for the British Association, would serve to give an idea of the extent to which the rainfall was influenced by an increase of elevation, and it would be seen that the difference in the registered rainfall was much greater than would have been supposed at different heights :—

Position of Gauge	Depth for three years	Average depth for one year
First gauge on the surface of the ground .	64·430	21·477
Second gauge on an elevation of 43 ft. 8 in. above the ground	52·169	17·389
Third gauge at an elevation of 212 ft. 10½ in. above the ground	38·972	12·991

It must, however, be admitted that the rainfall on July 14, 1875, and on the night of the 15th, was unusually heavy and continuous. It was, however, mentioned in the Metropolitan Main Drainage Report, that an equal, if not greater, rainfall occurred in the Holborn and Finsbury districts in London on August 1, 1846, on which occasion it was stated that four inches of rain fell in one hour; but of course that rainfall was limited to a comparatively small area.

Although the flood of July 14, 1875, had not been equalled within the memory of any living person, it appeared by the Trevethin Parish Records, that 102 years before, or in the year 1773, there was a similar flood; and that the ancestors of a family now living at Trosnant, Pontypool, whose property suffered damage by the last flood, then experienced a loss from a similar occurrence.

In India and other tropical countries, much heavier rainfalls were of frequent occurrence, and were carefully provided for in the hydraulic engineering works of such countries; in India especially, great scientific skill was brought to bear in the construction of such works. In this country it was usually considered that a rainfall of three inches in twenty-four hours might be taken as the maximum quantity to be expected; but in all engineering works it was always advisable to provide a wide margin against exceptional risks.

It must not be inferred, however, that in the case under consideration the rainfall was of such an exceptional and unprecedented

character that no ordinary precautions would have been adequate to meet the danger, for if the Cwm Carne Reservoir had been in a proper state of repair, and had been provided with proper appliances for letting off the storm water, it would, of course, have been as safe as other reservoirs in the district, which were subjected to similar conditions without injury.

As regards the cause of the accident, it was quite evident from the appearance of the embankment of the Reservoir, and from the levellings, that there had been a considerable subsidence towards the centre of the embankment, and that fact was fully confirmed by the evidence of the witnesses at the inquest, who first saw the water running over the centre of the embankment of the Reservoir for a width of many yards.

That subsidence was, no doubt, occasioned by a leakage through the centre of the embankment, which, according to the evidence of several witnesses, had existed for a number of years in the form of two permanent leaks, one of which supplied sufficient water at all times to fill a 3 or 4-inch pipe.

As the breach in the embankment occurred on a dark night, it cannot be positively stated whether the leak in the embankment, or the overflow at the top, was the immediate cause of the accident; but in all probability the latter was the more immediate cause, although the leaky condition of the embankment would naturally contribute to the result.

It was stated at the inquest that it was not unusual for the water to be running over the top of the embankment during heavy floods, and that it was generally in a wet and sloppy condition; and it was quite clear that such must have been the case on those occasions, as the difference in level between the top of the embankment and the sill of the waste-water weir was not more than 13 inches at the centre portions of the embankment; and no doubt that depression in the centre of the embankment must have been attended with the greatest danger, as there was nothing but the turf to prevent the soil from being scoured away

by any overflow of the water; and a channel being once formed, it would be impossible to avert the accident.

To have ensured the safety of the Reservoir the shaft of the principal sluice opposite the centre of the embankment ought to have been rebuilt, and raised some few feet above the surface of the water when full; and a stage or other communication made therefrom to the embankment, and proper appliances provided for readily raising the sluice in case of any emergency. That sluice, when in proper working order, would have been capable of discharging about 184·6 cubic feet per second, and had it been available on the night of the accident, and if the embankment and waste-water weir had been of the proper construction, it is more than probable that the accident would not have occurred.

It could hardly be considered safe and prudent to have allowed the water in the Reservoir to have attained a level within a foot, or even two feet, from the top of the embankment, as under such conditions the Reservoir would undoubtedly have been unsafe; and taking into consideration the defective state of the embankment, it was evident that the waste-water weir should have been lowered at least four feet below the level at which it was placed, which could have been done at a very trifling expense. In the event of any necessity arising for keeping the water at a somewhat higher level, it might have been effected by placing a moveable sluice board across the opening. Had the waste-water weir been placed four feet deeper than it was, it would have been capable of carrying off about 389·9 cubic feet per second, without the level of the water rising higher than within a foot of the top of the embankment; and assuming that the overflow weir had been deepened to that extent, and that the outlet sluice at the deep culvert had been available, the means of carrying off the inflow of storm water would have been increased to the following extent, viz.:—

	Cubic feet, per second.
No. 3 Culvert, or Deep Sluice	184·6
No. 2 do. or Middle do.	115·0
No. 1 do. or Upper do.	78·4
Overflow Weir	389·9
Total cubic feet per second	767·9

Thus providing an outflow for storm water considerably in excess of the estimated inflow from all sources, which amounted to 561·40 cubic feet per second.

Although the sluices numbered 1, 2, and 3 were much too small to meet the requirements of a reservoir having such a large inflow of water on ordinary occasions, as that at Cwm Carne, probably the water would have been safely carried off had the means which have been suggested been in operation at the time the accident occurred. It may, perhaps, be argued that, as the Reservoir had been in existence for so many years without the embankment giving way, nothing short of some special act of Providence could have caused so unforeseen an accident; but such an argument, however plausible and satisfactory to superficial inquirers, was entirely contrary to every principle of scientific investigation, and could not be entertained as a satisfactory explanation of an accident which arose from strictly natural causes.

From the investigation of the causes that led to the unfortunate accident at Cwm Carne, it may be safely inferred that no structure of that kind, however long it may have been in existence, could be considered safe without constant attention and supervision; and that as embankments of reservoirs never change their nature, or become consolidated like ordinary strata, it was evident that such structures would never acquire that permanently safe condition which characterised all accumulations of water in natural ponds and lakes.

Referring to the old leaks in the embankment, which had been frequently repaired by driving down "puddle" at the top of

the centre of the embankment, and which system of "tinkering" had been going on as long as any one could remember; it may also be safely inferred that when once a leak had been established in an embankment of that kind, no efforts in the shape of puddling, or patching the embankment, could effect any permanent cure, for, when once a channel had been established, the water continued to force its way through, owing to the great pressure, and if stopped in one place, would probably soon force its way out in another. In such a case it would appear that the only safe and reliable method of overcoming the difficulty was to make a new embankment, and to adopt such improved principles in its formation as would ensure a sound and solid construction.

In conclusion, it may be stated that the writer has made every endeavour to investigate the causes of this lamentable catastrophe with the strictest impartiality, based on a careful examination of all the attendant circumstances, and a close inspection and accurate measurements of the embankment and Reservoir.

PROCEEDINGS.

13th April, 1877.

The Ordinary General Meeting of the Institute was held at the Royal Hotel, Cardiff, on Friday, the 13th of April, 1877.

Mr. JAMES BROGDEN, F.G.S., President, in the chair.

The Minutes of the last General Meeting were read and confirmed.

ELECTION OF NEW MEMBERS.

The President announced that the Ballot Lists had been opened by the Scrutineers, and declared the following gentlemen to have been duly elected Members of the Institute, viz. :—

As Members.

Mr. Robert J. D. Burnie, Engineer and Managing Director, Wagon Works, Swansea.
„ Henry George Bolam, Agent to the Earl of Shrewsbury, Little Ingestre, Stafford.
„ Arthur D. Morrison, Engineer and Iron Master, Newnham.

As Graduates.

Mr. E. Roger Lewis, Student of Mining Engineering, Hirwain.
„ Daniel Thomas, Assistant Colliery Manager, Gelly Colliery, Ystrad-Rhondda.

ADMISSION OF NEW MEMBERS.

The following gentlemen, elected at previous meetings, were then formally admitted to the Institute by the PRESIDENT, and signed the Roll Book, viz.:—

Mr. F. L. Lester, Maesteg.
,, Sl. Hy. Stockwood, Maesteg.

The discussion of Papers read at previous meetings was then proceeded with.

ADJOURNED DISCUSSION ON THE "PENCOED, MYNYDD-Y-GAER, AND GILFACH-GOCH MINERAL DISTRICTS."

The PRESIDENT said their first business was to resume the discussion of Mr. Henry K. Jordan's Paper on the "Pencoed, Mynydd-y-gaer, and Gilfach-goch Mineral Districts," which he considered to be a valuable addition to their knowledge of that portion of the coal-field. He had lived between the outcrop of the "Malthouse" vein and the "Rock Fawr" for many years, and knew the district well; the identity of the latter seam with the "No. 3 Rhondda," referred to by Mr. Birbeck and others, was a matter of considerable interest.

Mr. THOS. JONES PRICE thought that the correlation of the coal seams which had been referred to by the President was a most important point; but, at the same time, a most difficult one, upon which, however, he would make a few observations later on.

He regarded the series of Papers on the different Districts of the Coal-field, which had been brought before the Institute from time to time, to be very valuable; and he believed the particular area or District then under discussion was of more than local interest, for it comprised a considerable mineral tract to which much attention had been directed in search of the "Lant-

wit Coals;" and a further extensive tract where, if continuous, the "Rhondda Series" might be expected to be found at shallow depths, and within easy access of railway facilities; whilst the "Lower Measures" constituted a grand reserve of bituminous Coal, capable of conversion into Coke of a high character, large supplies of which would probably be drawn from that source in the not far distant future.

The Paper under discussion was a very able one, evidently the result of much original investigation, and containing valuable details of altitudes and measured angles of dip, supplemented by conclusions and suggestions which had the great merit of being distinctly expressed.

Commencing with the Faults and confining himself to the lower portion of the district, as being in his more immediate neighbourhood, he took first the "Moelgilau Fault," which had been locally described in previous Papers, where they had been told that such was its magnitude at Cwmavon, that a seam of coal, probably corresponding to the "Rhondda No. 2," found on one side of that Fault, was on a lower level than the lowest seam in the Coal measures on the other side; whilst in the Llynfi District Mr. Barrow had attributed to it the enormous dislocation of 1,200 yards; and in the Garw Mr. Birbeck had ascribed to it the more moderate, but still extensive, upthrow of 300 yards; whilst the observations in the Paper then under discussion led to the inference that in the little Ogmore that important dislocation had diminished to comparatively small dimensions.

The continued diminution eastward of the dislocation caused by that Fault was certainly remarkable; but an examination of the rapid dip of the strata south of the anticlinal in the Ely and two Ogmore Valleys, as compared with that in the Llynfi Valley, should prepare them for some such result. Other causes might, doubtless, have contributed; but he was not able to concur with the Author in believing that the roll in the strata, or minor anticlinal, affected it, and was inclined to think that the elevation at

the ridge of this roll was sufficiently accounted for, without assuming any upheaval at the synclinal, by the dip of the strata under Mynydd-y-gaer, where it was more rapid than in other places to the west at similar distances from the synclinal. But he agreed with the Author, and thought he had suggested the true explanation, when he said that the greater dip in the east with a diminished Fault was equivalent to the lesser dip plus the extensive dislocation in the west.

These were general considerations; but an examination of the Author's measured angles of dip brought the matter to a point; if it should be thought that the effects of frost, or infiltration, might have rendered the apparent dip at the bassetting greater than the true dip, and that any error had arisen from that source (although he wished to guard himself from implying that there was such an error), then the Dimbath Borehole came in to show that it must be confined within narrow limits; and thus the horizontal section became instructive, and, to his mind, showed, on the assumption of the Rock Fawr being the correlative of the "No. 3 Rhondda," that in the little Ogmore this great Fault appeared as a comparatively small displacement.

Passing on, he came to the Glynogwr NE. upcast Fault, the interest of which arose from the suggestion that it was a continuation of the Glyncorrwg Fault; and he would here express regret that the Plan contributed by the Author about two years ago, in which he laid down the course of the latter Fault, had not been subjected to discussion; it traced a Fault from Glyncorrwg across the Afon Valley to Nantymoel; and if the Author were now able to show that the Nantymoel and Glynogwr Faults were one, he would have accomplished a great point in having traced the Glyncorrwg Fault as far as the little Ogmore; there had been some doubt, however, whether the suggestion of the Glynogwr and Nantymoel Faults being identical was compatible with certain mining explorations in the Ogmore Valley, and it had been suggested that possibly the Nantymoel Fault diminished and disappeared near the anticlinal; it was also not improbable that the

Glynogwr Fault took its origin near this line, developing into a large displacement in the little Ogmore, thus accounting for the rapid easterly dip in the Dimbath Valley pointed out by the Author; it was known that a Fault took its origin in the Ogmore and rapidly expanded into a step of about 20 yards, with indications of increasing southwards; but whatever be the true reading, the Author had done good service in drawing attention to it.

Passing on to the next Fault, the 85-yard upcast NE., he understood that it had been recently intersected near Nantymoel.

With regard to the Roll in the strata, or the minor anticlinal, he was inclined to think that it was not the only one, but that another probably existed nearer the outcrop, and that similar waves were observable in the mountain limestone through the vale of Glamorgan, and he had been in the habit of attributing the tenderness of the coals and the attendant shales in some parts of that district to the contortions to which they had been thus subjected.

Passing on to the next point—the identification of seams—the only contribution he could make was an expression of opinion that the "Rock Fawr" occupied a similar position to that of the "Tormynydd" at Maesteg, and to the seam known as the "No. 3" in the Ogmore and Garw Valleys; he believed that Mr. T. G. Davies had identified the "Tormynydd" with the "Rhondda No. 2," but in a subsequent discussion Mr. Barrow considered it to be the "No. 3 Rhondda;" if that were so, then the "Rock Fawr" corresponded in position with the "Rhondda No. 3." He felt little hesitation in recognising, in the "Hendrewen" Seam, the "White Seam" of Maesteg, and "Double Vein" of the South Crop, and a seam or two below had their counterparts at Maesteg; but immediately above the "Rock Fawr" there was some obscurity, and they yet wanted a verified section at that point.

There was one other subject: the author had devoted considerable thought to the westerly rise, and pointed out the remark-

able influence it would have had upon the coal-field if there had not been compensating faults; but the speaker was unable to consider it apart from the faults, for he regarded it as the direct result of the faults; for where a series of dislocations occurred, with the steps all in the same direction, a rise in the strata, between the steps, in the direction of the downthrow, would be the natural consequence; and as in this district the faults were principally downcasts west, the westerly rise was a consistent accompaniment.

On other points touched upon by the Author he concurred generally, and believed that the principal features of interest which were known had been brought forward, throwing considerable light on the district, and he felt sure that the result of the Author's labour had been to add much to their knowledge of a district which he had truly described as difficult to decipher; it was difficult, inasmuch as it involved a correlation of seams in the upper and lower series, in order to obtain a common point of departure from which to approach the Moelgilau Fault; and difficult by reason of the steep and uncertain inclination of the strata in various places, and the magnitude, or supposed magnitude, of previously unexplored faults.

Probably it might be interesting to mention that there were indications of a new industry commencing to spring up on the borders of that district, in the form of lead-mining in the mountain limestone, and from which the first parcel of galena had, a few days before, been sent to Swansea. Its occurrence was similar to that in the north of England, the matrix being sulphate of baryta in some places, and carbonate of lime in others; he had placed one or two specimens on the table for inspection.

Mr. Hugh Begg said that he had made some remarks on Mr. Jordan's Paper at the previous Meeting touching the distance between the "No. 2" and "No. 3" Rhondda Veins. Mr. Jordan had expressed his opinion that 90 yards was the normal distance between the two seams, whereas in the Rhondda Valley it was found to be much under 80 yards, some of the sections measuring under

70 yards. But through the Rhondda Valley there would be considerable uniformity if the "Forest-Fach" Coal, at the foot of the Valley, be called the "No. 2" Vein. At Pontypridd the Forest-Fach Vein was within 4 or 5 feet of what was called the "No. 2," but at the Great Western Colliery that distance had increased to 8 yards, which closely corresponded with the distance between the "No. 2" and the "Three Coals" at Lwynypia, Dinas, and Gilfach-goch. The distance, however, between those seams thickened towards the west, and Mr. Jordan stated, at pages 73–74 of No. 2, Vol. X., that "At Gilfach-goch it "was about 90 yards, and in the Ogmore, according to the "levellings of Mr. Birbeck, no less than 125 yards, and the "mean of three measurements in the district under notice was "97 yards," but in the district under discussion he was not aware that there was any sinking from the "No. 2" to the "No. 3." In the little Ogmore, pits had been sunk to the "No. 3" to the west of the line of Mr. Jordan's section, but none of them had gone through the "No. 2."

Mr. Henry K. Jordan said that at Gilfach-goch the "No. 2" seam cropped out just above the top of the pits, the depth of which to the "No. 3" seam was upwards of 90 yards.

Mr. Hugh Begg said that at Gilfach-goch there was an adit level driven for about 200 yards across the dip of the measures, which intersected the "No. 2" within some two to three feet of the level of the top of the pits, but if the rise of the coal, where struck, be continued back towards the pit, it would bring the "No. 2" coal about 20 yards above the pit top, or, if taken on the same line of section over the Little Ogmore brook, it would place the "No. 2" coal about 30 yards or more above the level of the brook, whereas the "No. 2" was wrought at that level, showing that there was a fault throwing down to the west on that line; and the pits at Gilfach-goch were sunk through faulty ground for a considerable distance.

Mr. Jordan had also stated at page 74, No. 2, Vol. X., "that "the 85-yard Fault was actually proved in Penygraig Colliery

"before his Paper was written, and that since its publication the "Fault had also been struck at Gilfach-goch Colliery," and had shown a Fault of 85 yards rising north-east at Penygraig and Carncelin, and also another upcast Fault north-east of 65 yards, further north in the line of section. The Penygraig Colliery plan showed a fault of 80 yards rise to the north-east, but it must be very local, for no fault greater than 7 yards was to be found along the whole length of the Dinas property where it joined the Penygraig on the north side, and no fault of more than 11 yards was to be found in the Penrhiwfer property, which adjoined the Penygraig all the way along its south boundary, and neither the Penrhiwfer, or the Dinas working-plans, showed any fault of the dimensions named by Mr. Jordan.

He would be glad if Mr. Jordan would state his views as to the correlation of the seams at Llwynypia with those of the other steam-coal districts. He did not think there could be any question as to the identity of the "No. 3" at Llwynypia, but in respect to the lower or steam-coal veins opinion was much divided. Mr. Jordan gave the "Abergorci" Vein under the "No. 3," whilst at Llwynypia it appeared in two coals of about 20 inches each with some 13 feet of ground between them, and the "Pentre" Vein, 13 yards under it, was 27 inches in thickness, and proved a very fair coal, but had been omitted in Mr. Jordan's section; and the following, of what may be properly called the steam-coal seams, had also been omitted from his section, viz.: at a depth of 312 yards down the pit a seam of coal 2 feet thick, then a bed of fire-clay, 1 foot 2 inches, and then coal 10 inches, which corresponded remarkably closely with the "Two Feet Nine" coal at Ferndale. Some 13 yards lower there was a vein of 4 feet 3 inches of solid coal omitted, which was a good steam-coal. Passing 12 yards further down there was another seam omitted, with coal 2 feet 1 inch, shale 9 inches, coal 1 foot 1 inch, and between that and the vein now at work there were several minor veins that had been omitted from the section. The seam which was being worked had the following section:—

	Feet.	Inches.
Coal	5	4
Shale	0	2
Coal	2	0
Total . . .	7	6

which Mr. Jordan called the "Six Feet," but he had never heard it so called before; as they were probably aware, there had been a good deal of controversy as to the identity of that seam, and the coal 48 yards above it, which was 4 feet 3 inches thick, and it had been declared by very competent authorities not to be the "Four Feet," but he had never heard either described as the "Six Feet." He thought that on the Ton Section the 7 feet 6 inches coal was described as the "Nine Feet," and generally worked and paid for under that title; so that the question of the correct correlation of the lower seams at Llwynypia was a matter of much interest.

The PRESIDENT confessed that the subject of the correlation of seams was one of great difficulty in any country; it did not matter where it was, for it was seen that within very short distances one seam frequently varied very considerably. He instanced the "Cae David" and "Abergorci" seams, which were of a similar character in some places, but which were divided by shales, which suddenly came in at others, and altered the character of the seams entirely, until they were scarcely recognisable. Something of that kind had probably taken place upon a large scale in nature, in every coal-field, more or less, which became evident in making out sections at different places. There could be no question but that the coal-fields of South Wales, and the Forest of Dean and Bristol and others in Great Britain, and those of Belgium, must have been deposited about the same time, and been a continuous coal-field. When the great difference in the character of the seams throughout the whole of that wide area was considered, it was almost impossible to understand how such varying characteristics should have occurred. No doubt the changes in the seams and in the

nature of the coal had been brought about by atmospheric influences, by the changes which would be effected by water, or it might be the action of hydrogen or the quantity of oxygen absorbed under the various circumstances. And so, perhaps, in that way the different qualities of the coal could be satisfactorily accounted for. Then disturbances occurred, which changed and rolled the seams about, and where that took place, as in their own district, the character of the stratification was changed.

There was a peculiar change in the nature and characteristics of the coal in the southern part of the South Wales basin, which some persons had ascribed to the faults traversing the district.

It was rather remarkable that the section of the south crop was so much richer in coal than that of the north crop. He would suggest that the section of the pit at Llwynypia be given in detail; and he thought as many of the sections of other pits sunk within the district as could be obtained should be contributed by Members; because the changes which occur in the character of coals—the size, thickness, workable capabilities, floor, and so on—were so multifarious that in one district a seam might be worthless and in another very valuable, and the information shown upon the sections would be of great advantage to the Members.

He confessed that he did not see any reason for supposing the "Rock Fawr" to be the "No. 3." It appeared to him that it was beyond human power to establish their identity, because the Moelgilau Fault was greater than Mr. Birbeck supposed, and appeared to have destroyed the whole chance of recognition between the seams on the north and south of it. Allowing for what he had said, that seams changed all their characteristics within short distances, they might still to be able to identify the coal themselves.

Now, the "Rock Fawr" and the "Malthouse" coals, and those in the south crop, were exceedingly similar in their working, and had a peculiarity which scarcely belonged to any other coal. They had had them brought out in small like dust, dry

as powder, and, in fact, too dusty to put upon a fire, and yet no steam-coal that he had ever seen burning raised more steam than the "Rock Fawr," and he had never yet met with a coal that would get more steam than those seams. A few, indeed, in the upper pennant rock series, in the Aberdare district, performed the same duty. He thought that was a characteristic which would show itself in the "No. 3 Rhondda," that it would have somewhat of the steam character within the short distance of which he was speaking, which was only a few miles from a district where the "Rock Fawr," in the comparison with "No. 3," did agree fully.

Again, taking the section from where the "No. 3" was admittedly present in the Ogmore, and continuing the section, and making allowance for Moelgilau Fault at Caeda, as described by Mr. Birbeck, he could not reconcile himself to the view that the "Rock Fawr" was identical with the "No. 3." He thought the fault had thrown the "No. 3" down to such an extent that they had a perfectly different section one side of the Fault from the other.

He confessed that the lower coals must be more difficult to recognise than the upper, and thought that instead of beginning at the top they should begin at the bottom in the identification, because no coal could have existed below the lowest series. They may imagine and account for a great many of the upper seams being washed away and denuded; but by no possibility could a lower one disappear first. They did change, and it was doubtful from their nature alone how far the seams could be recognised; and, altogether, he thought correlation was a most difficult subject.

He might mention, however, that the Council had appointed a Committee for the purpose of endeavouring to identify the various seams in the different districts, so that he hoped the question would receive the most complete investigation, and be brought to a successful conclusion, and be of much service to the Institute.

The Paper under discussion was most valuable as a great guide to those persons who were likely to become future adventurers in the sinking of pits and opening of colliery works in that district.

Mr. HENRY K. JORDAN, in reply, said that he agreed with Mr. T. Jones Price in considering the coal measures' strata to be somewhat more highly inclined at their outcrop, owing to exfoliation, which doubtless resulted from frost action, infiltration, &c.; and for that reason the thickness of strata obtained by measuring with the clinometer was greater than the true thickness. In making his horizontal section, he invariably measured the inclination of the lowest exposed beds, so as to guard against error as much as possible.

With regard to the Glyncorrwg Fault—which was the most important Fault in that area of the coal-field—he had successfully traced it from the Vale of Neath, southwards, to Mynydd-y-gaer, which was about three-fourths of the entire width of the coal-field; and he had been able to show that the opinion so long and generally held as to its course was erroneous. It was his opinion that that Fault passed out of the coal-field at some point not far from Llantrissant Station.

He agreed also with Mr. Price that there were circumstances which pointed to the probable existence of another large roll in the Pencoed district, but at present nothing definite could be stated in regard to it.

With regard to the *westerly rise* of the strata, he could not concur in the opinion expressed by Mr. Price, that it probably resulted from the Faults, the great majority of which were, as stated by that gentleman, downthrows west. If downthrow west Faults gave a westerly rise, then *upthrows* west should give a westerly *dip*, but such was not found to be the case, the westerly rise being persistent, irrespective of the direction of the throw of the Faults.

In reply to Mr. Begg he stated that the distance between the "No. 2" and "No 3 Rhondda" Seams varied very much, but it

might be taken as averaging about 90 yards in the district under notice.

The 85 yards Fault shown in the Plan—the existence of which Mr. Begg still doubted—was proved in Penygraig Colliery, having raised the "No. 3 Rhondda" Seam to the level of the "No. 2" Seam.

Mr. BEGG said that if that were so it must, in his opinion, be local, or it would have crossed the Dinas property on the east, or Penrhiwfer on the south.

Mr. HENRY K. JORDAN remarked that the course of the Fault was to the west of the Penrhwifer Pits, which accounted for its not having been proved, as yet, in that colliery.

The seams of coal which Mr. Begg mentioned as being omitted from the Horizontal Section were purposely left out to avoid overcrowding, as expressly stated in his Paper.

In respect to the steam-coal seam worked at Llwynypia Colliery, he regarded it as being the "Six Feet" Seam of Aberdare. He regretted the absence of Mr. W. G. McMurtrie, whose opinion upon that point it would be very desirable to have. Mr. Begg himself had had considerable experience in the Rhondda district, and it would be well if that gentleman would state his views as to the identity of the seam in question.

In reply to the President he stated that the difficulties in the way of correlating the seams of coal in the different areas of the coal-field were very great, owing to the variations of thickness, quality, and section, which were found to occur in many seams of coal, even in a short distance.

So great were these variations in some instances that not the slightest resemblance remained.

That fact, he considered, should meet the objection of those who, on account of the great difference in the quality of coal, hesitated to agree with him in the opinion that the "Rock Fawr" and "No. 3 Rhondda" Seams were identical.

Another difficulty in the correlation of seams was the variations in the thickness of strata between many of the seams

of coal, and it was only by tracing, step by step, the gradual but great westward thickening of the strata, that success was attained.

It would be remembered by those who had read his Paper, that he had been guided in his work of correlation by a remarkable bed of Yellow Rock, which could be traced over large areas; and taking this Yellow Rock as a starting-point, both in ascending and descending order, it would be seen that many of the seams of coal, and the "Cockshot Rock," in the Maesteg district, agreed very closely with the "South Crop" Seams, as was shown in the Comparative Sections which accompanied his Paper.

He would take that opportunity of saying that he had placed upon the table some specimens of *Coal Pebbles*, and Coal Conglomerate, from the roof of the "Rock Fawr" Seam, and from the Pennant rocks, in the neighbourhood of Bridgend. He stated that the pebbles were of great interest as showing that coal was to a great extent consolidated before the roof material of the seam was deposited; also that seams of coal which had roofs of Pennant rock had been reduced in thickness, and in some instances destroyed, by the strong water currents which distributed the roof material.

The specimens exhibited had been collected to illustrate a Paper about to be read before another Society, for which reason he was unable to speak more fully upon the subject, but, as the opportunity had presented itself, he had brought the specimens for the inspection of the Members and Visitors present at that meeting.

Mr. Begg thought it was quite immaterial whether there were 80 or 90 yards between the "No. 2" and "No. 3." He believed, with Mr. Jordan, that there was a thickening of the measures going westward. In reference to the Fault on the Penygraig property, he had the working plans of both the Dinas and Penrhiwfer colliery properties, which surrounded it, and that Fault did not appear to run into either of them, though, if existing, it should run into both those properties; but, as he had before stated,

there was no Fault on the Dinas property measuring more than 7 yards, and only one in Penrhiwfer, measuring 11 yards, but throwing in a different way. The correlation of the veins in the Rhondda was a matter which had been often discussed amongst the leading engineers, and he rather hesitated in giving an opinion, but it had been contended that the 7 feet 6 inches vein, then being worked at Llwynypia, was the "Nine Feet" Seam; and in respect to the 4 feet 3 inches vein, that was 48 yards above it, it was disputed whether it was the Aberdare "Upper Four Feet" or not.

The PRESIDENT said that it was now their duty to thank Mr. Jordan for his very able Paper, which was particularly valuable in that it formed the connecting link to that portion of the coal-field, and dealt with the district in a most lucid and conclusive manner.

A vote of thanks was then accorded to Mr. Henry K. Jordan for his valuable Paper, and the discussion was adjourned to the next meeting.

DISCUSSION ON "THE DRAINAGE OF THE TAFF VALE DISTRICT."

The PRESIDENT said this was a Paper by Mr. Alexander Bassett, read some time since, but of which they had been obliged to postpone the discussion until that day, in consequence of the absence of the Author.

Mr. ALEXANDER BASSETT said that before making any remarks on his Paper he must first apologise for his absence at the last meetings, which rendered it necessary for the discussion of his Paper to be postponed until that day.

He had had much pleasure in complying with the wish expressed by the Members at the last meeting, that he should prepare a general plan of the district proposed in his Paper to be drained. The plan on the wall showed the district from the Bristol Channel, in the neighbourhood of Cardiff, to Treforest, Aberdare Junction,

Aberdare, Ferndale, Treherbert, and Porth; those being the Valleys through which he proposed the main culverts to be constructed. The average inclinations of those Valleys were as follows, viz.:—

From Aberdare Town to Aberdare Junction	1 in 263
,, Aberdare Junction to Treforest . .	1 in 217
,, Ferndale to Porth	1 in 53
,, Treherbert to Porth	1 in 141
,, Porth to Treforest	1 in 152

At Treforest the sewage waters from the Rhondda and the Aberdare districts could be connected and passed from that point southwards in one culvert. The inclination from Treforest to Cardiff would vary from 1 in 300 to 1 in 500.

As he stated in his Paper, the primary object appeared to him to be the collecting and carrying away as quickly as possible all the sewage matters from the above districts; the other question, as to how the sewage was to be disposed of, was, in his opinion, quite a secondary consideration as compared with the former.

He thought it would be admitted that between Cardiff and Marshfield there was a very great extent of land sadly requiring manure, and which was conveniently situated for receiving the sewage waters from the Taff district. That area was water-logged in the winter, and in the summer it suffered considerably from the want of moisture. Some years ago he mentioned that fact to Mr. Clutton, who was probably one of the greatest authorities upon the question of reclaiming and improving land. He then expressed the very decided opinion that the low lands between the rivers Rumney and Ebbw, to the south of the South Wales Railway, if placed under proper management and supplied with ample manure, either in the liquid or solid form, and properly drained, ought to be at least doubled in value.

The experiments he made on property belonging to the Right Honourable Lord Tredegar in the neighbourhood of Cardiff, and to which he referred in his Paper, most clearly proved the important results that had been obtained from the application of sewage waters as manure.

He had recently professionally reported upon the Mountain Ash Drainage, where he had recommended that the sewage should be used for irrigating the lands between Mountain Ash and Aberdare Junction. He was decidedly an advocate for using sewage waters for the purpose of irrigation wherever it was practicable, rather than allow them to be lost either by being passed through filtering beds or discharged into the sea.

He had reason to believe that the Members of the Institute would agree with him that isolated systems of drainage in such a crowded district as the Rhondda Valley could not possibly be successful; consequently he was of opinion that nothing short of a comprehensive scheme of the character he had suggested would meet the requirements of the district.

He might here state that he had mentioned his Scheme to Lord Aberdare and several other gentlemen, whose opinion on a subject of that kind was valuable, and they admitted that such a project would be most desirable. Of course he acknowledged that there were difficulties in the way of carrying out such a comprehensive scheme, but at the same time he saw no reason why they should not be overcome, and all interests properly and fairly adjusted.

Taking his estimate at £100,000, and borrowing the money, as suggested in his Paper, it would appear that the payment of 4*s.* $1\frac{3}{4}$*d.* per house per annum was a most moderate sum to be paid, considering the important objects attained by a perfect system of main drainage for so large and important a district as that under consideration. He might here remark that, the gradients being so severe in the valleys, the culverts he proposed would vary from 2 feet to 3 feet 6 inches in diameter, which would be capable of discharging five times the quantity that was likely to be produced from the district during the 24 hours.

It might be said that there were areas in the Taff Valley where the sewage waters could be profitably applied for irrigation purposes, but the surplus quantity would have to be taken either to the sea or on the marshes near the Rumney River, as

the land in the Taff Valley available for that purpose was very limited, as compared with the population in the valleys.

Mr. Begg inquired if there would be any difficulty in taking the sewage on to the table-land west of Treforest.

Mr. Bassett thought there would not be the slightest difficulty; but he was not prepared to say, without having levels taken, whether it would be necessary to have recourse to pumping, or whether the sewage could be discharged in the district referred to by gravitation alone.

Mr. Begg said that it had occurred to him that the table-lands between Treforest and Llantrissaint were capable of much improvement; and if the sewage could be utilised there without much difficulty, it would be less expensive than carrying it down to the Cardiff Marshes or the Bristol Channel.

Mr. Wilkinson said there were only two ways of disposing of the sewage, and he thought that they would shortly be compelled to take action in the matter by the central authorities. It must either be disposed of in the valleys or dealt with as suggested in Mr. Bassett's Paper. He thought a small engine to pump it up the mountain-side would be cheaper than conveying it to Cardiff, and be of some benefit to the neighbourhood.

The President said that the question of pumping became a very serious one. It would no doubt be desirable, if sufficient land could be found, to receive the sewage of each valley without conveying it to such long distances, as suggested by Mr. Bassett. It appeared that one acre of land would fulfil the requirements of 1,000 persons—that is, if intermittent filtration is the system adopted—and under the circumstances it would depend upon the cost, to a great extent, what system was adopted.

From the reports that were before him, the question had been studied most thoroughly, and various systems had been and were being tried, but it appeared that by the filtration process each individual in a town is supposed to be worth 10*s.* a year. Mr. Bassett's calculation was that the capital to be raised would cost £4. 2*s.* 6*d.* per cent. per annum, which would be at the rate of

4*s.* 0¾*d.* per house per year. In other cases it had cost to every individual upon the rates from 1*s.* 6*d.* to 1*s.* 8*d.* per individual, according to the more or less expensive manner of its being carried out, expensive purchases of land, and so on; but it had been considered that the cost should be covered by an expenditure of 1*s.* 8*d.* per head of the population per annum. Mr. Bailey Denton, who was an authority on the matter, said that no method of disposing of sewage was so efficacious as his system of intermittent downward filtration; and further that if that system were employed in combination with others, such as wide, open irrigation, it was capable of being worked more profitably than any other. But he made an important stipulation, that there should be a subsoil drainage to the depth of 6 feet, which he calculated would render one acre equal to the work of cleansing the sewage of 1,300 persons. Then came the question of utility, and from the returns it appeared that it cannot be made a profitable return to the town except by letting the land and making a small rate. Then two towns were given illustrating the cost of sewage works —Aylesbury and Abingdon. At Aylesbury, where the population was about 7,000, a patent precipitating process had lately been introduced, and the annual charge to the ratepayers for cost of works, lands, and appliances, added to the subsidy to be paid by the town, involved a charge on the ratepayers of 1*s.* per person.

Abingdon had a population of about 6,000, with 8 acres laid out in filtration areas, and 20 acres to open irrigation. The annual charge for land and works upon the town was £390; the land produced £150; and a deficiency of £240 was left to be provided by the town, which was equal to 9½*d.* per person.

Mr. Bassett said he had purposely abstained from considering the question of utilisation of sewage, as it appeared to him it would open so large a question. He had gone into the mere question of collecting the sewage, and to show how it could be done, and that by raising the money—taking, for argument sake, £100,000—at £4. 2*s.* 6*d.* per cent. per annum, and making it

repayable over a period of 30 years, that would give 4*s.* and something over per house per year, which would bring a collier's house to about 1*s.* 9*d.*, and larger houses more in proportion. But whether filtration, irrigation, or a mechanical contrivance was to be used must be left for further discussion.

The PRESIDENT said that the mode of application regulated some of the principal items of cost, and if it were known that other modes of disposal could be applied, it would form part of the question, provided the cost of the works was not excessive. Taking those parallel cases of Aylesbury and Abingdon, for instance, Aylesbury, with a process of precipitating the solids, costs the inhabitants 1*s.*, as against 9½*d.* at Abingdon, where they had filtration and irrigation combined, and that showed that the system of intermittent filtration was the cheaper.

Mr. JEE said that he saw no mention made of the size of the sewers, but assumed that it was proposed to have a larger size from Treforest along the lower course of the drain. No size was mentioned.

Mr. BASSETT said the inclinations from Aberdare and Treherbert being very rapid, he proposed a culvert 24 inches in diameter, and that would be capable of discharging 3½ million gallons per day. The quantity to be discharged at present, reckoning at 15 gallons per head, was 792,000 gallons. From Treforest down to the sea he proposed a culvert 42 inches in diameter, and that would be capable of discharging 7 million gallons per day, whilst the quantity to be discharged at present was only 1,883,000 gallons. Therefore those sectional areas of culverts, taking into consideration the great inclination, were more than five times sufficient.[1] Of course storm-water was not supposed to go into the culverts.

Mr. JEE thought it would be necessary to apply for an Act of Parliament, for in any other way it would be impossible to reconcile conflicting interests, and he did not think the Local

[1] The volume of sewage waters to be discharged per minute was calculated at half the quantity of pure water.

Board had sufficient power to authorise the construction without an Act.

The PRESIDENT knew that the Local Government Board had great powers, but whether sufficient for that purpose he could not say. He thought that the subject was so connected with the utilisation of sewage that the two things were only portions of the subject, and ought to be discussed together; and if Mr. Bassett would be good enough to amplify his Paper by another upon the best way of applying the sewage, it would be of much interest, and be better discussed.

Mr. BEGG inquired whether it was requisite to drain the soil to the depth of six feet for receiving the sewage.

Mr. BASSETT said of course sewage could not be put upon land unless it had been previously drained, and the question arises whether the land betwen Cardiff and Newport is not too low to be drained to that depth for discharge into the Channel. He did not think it was, but did not know whether it would be necessary to go down six feet for all purposes. For filtration no doubt that depth should be drained; but for irrigation, which he proposed, he did not think it would be necessary to drain deeper than three or four feet. The land would have to be specially formed, and the sewage taken over it in carriers. He thought perhaps it would be better to close the Paper now, and at some future time he might contribute a Paper on the utilisation of sewage; but the one under discussion simply dealt with a general drainage scheme. The disposal of the sewage was a question requiring further consideration, and would have to be specially dealt with hereafter.

The PRESIDENT thought they all agreed with Mr. Bassett in the necessity for sewage drainage; and it generally occurred that where there were the best opportunities of drainage the least was done, especially in a hilly country. However, whether the work would ever be carried out as laid down on the plan or not, there was an absolute certainty of the districts being compelled to deal with the subject before long, as the Legislature

would not permit the pollution of rivers. The discussion would now be closed, and he moved that the thanks of the Institute be given to Mr. Bassett for his Paper.

A vote of thanks was then accorded to Mr. Bassett for his valuable Paper.

The adjourned discussion of Mr. George Birbeck's Paper on "The Bryncethin and Ogmore Mineral District" was postponed to the next meeting, in consequence of the absence of the Author.

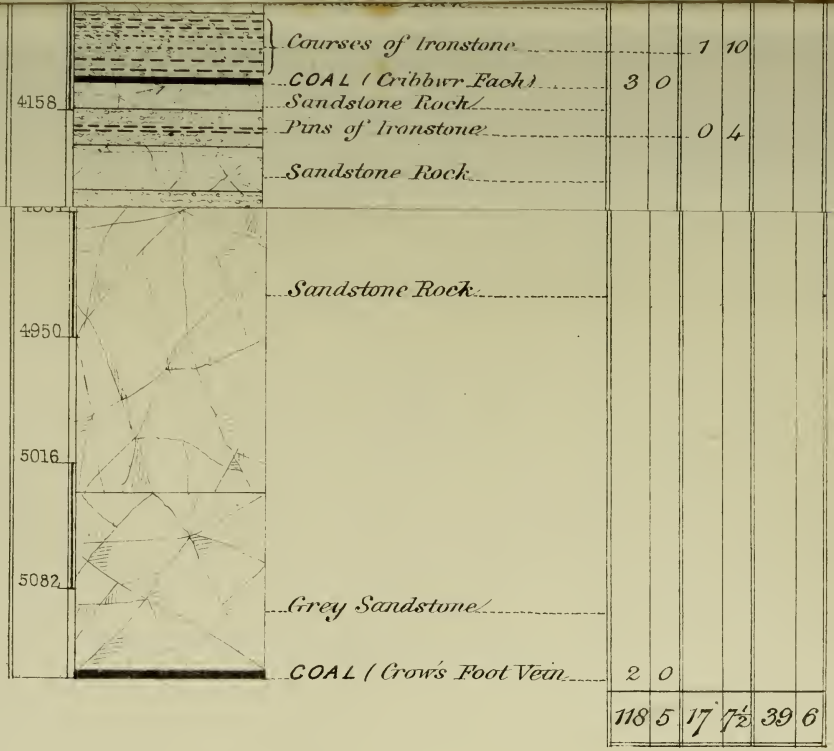
The discussion of Mr. Wilkinson's Paper on "Personal Experiences in Colliery Explosions" was taken as closed.

Discussion on "Natural and Furnace Ventilation."

The President said the next business was the discussion of Mr. Begg's Paper on "Natural and Furnace Ventilation," which was an interesting subject, affording ample scope for full discussion.

Mr. Wilkinson agreed with the views expressed by Mr. Begg in his Paper, which appeared to confirm the remarks that he (the speaker) had ventured to give to the Institute a short time since.

The President thought Mr. Begg was in the happy position of having most of the Members agreeing with him. Their collieries had long since passed the stage of depending on natural ventilation, and to a very large number furnace ventilation was a thing of the past. The requirements of the Legislature, and the necessities of deeper and more extended colliery operations, demanded a larger amount of ventilating power than could, with due regard to efficiency and cost, be obtained by furnace ventilation; and mechanical substitutes of various forms had now, at the largest and most fiery collieries,



Courses of Ironstone			1	10		
COAL (Cribbwr Fach)	3	0				
Sandstone Rock						
Pins of Ironstone			0	4		
Sandstone Rock						
Sandstone Rock						
Grey Sandstone						
COAL (Crow's Foot Vein	2	0				
	118	5	17	7½	39	6

(Proceedings S.W.Inst.Engs:1876) No1. Vol 10.

A.Reid, Newcastle on Tyne.

Plan

Accompanying Mr. George Barbeck's Paper on the

BRYNCETHIN, LLANGEINOR & OGMORE VALLEY, MINERAL DISTRICT.

Scale 24 Chains = 1 Inch.

Proceedings of S. W. Inst. Engs 1876 [N° Vol 5]

A. Reid, Newcastle on Tyne.

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LONGITUDINAL SECTION

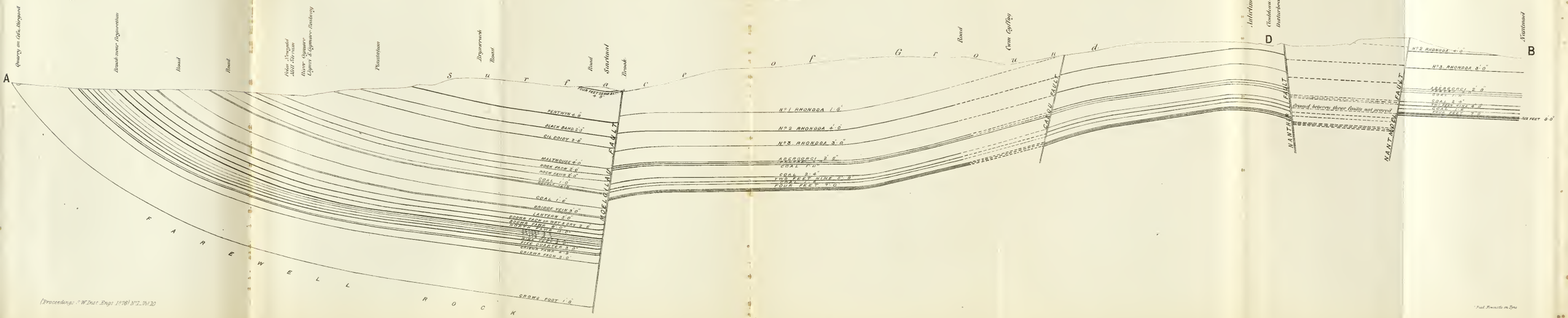
FROM

BRYNCETHIN TO NANTMOEL FROM A TO B ON PLAN,

Accompanying Mr George Birbeck's Paper

on the

BRYNCETHIN, LLANGEINOR & OGMORE VALLEY, MINERAL DISTRICT.



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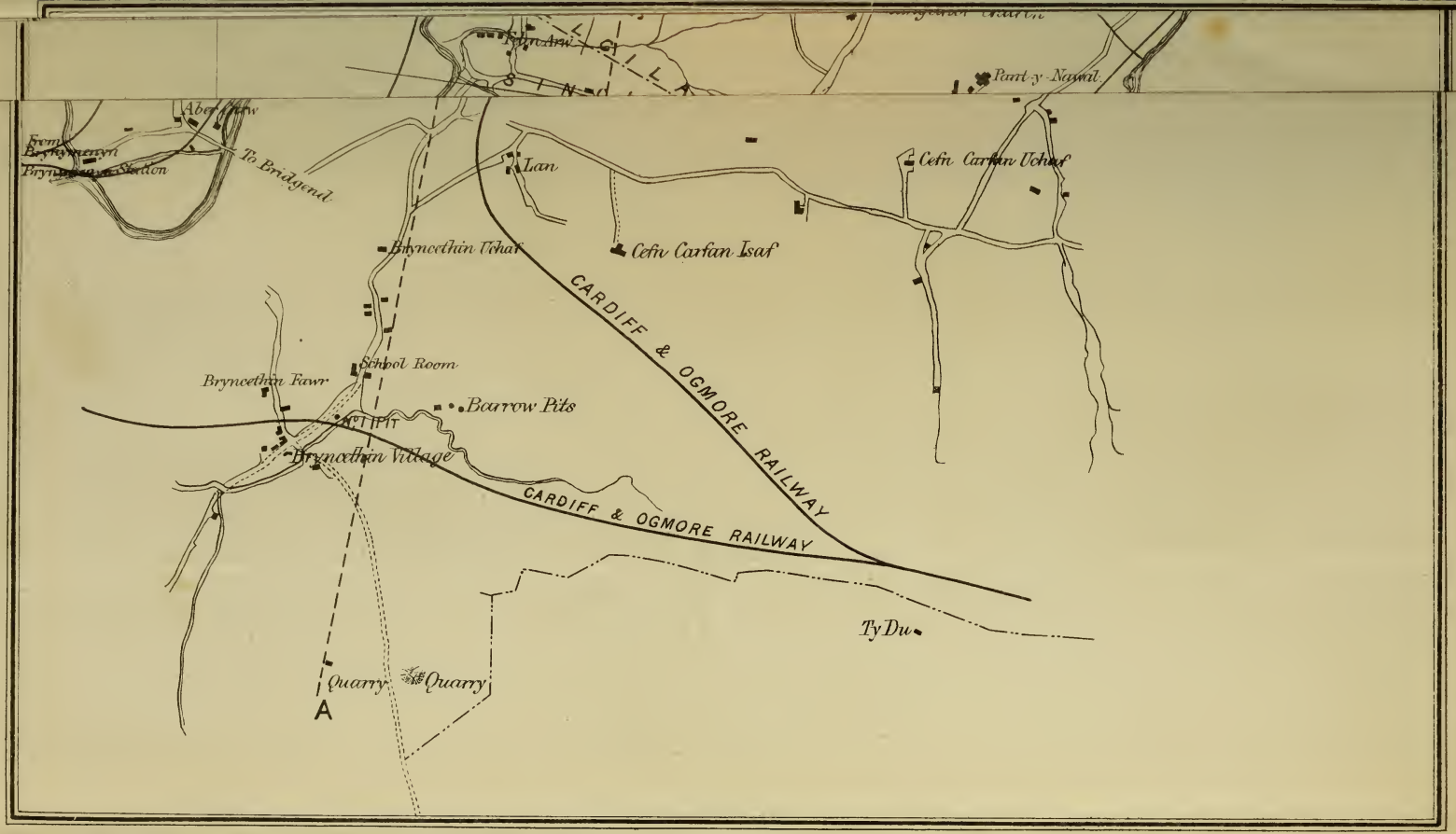
Prod. Newcastle on Tyne



(Proceedings S.W.Inst.Engs:1876) No; Vol 10

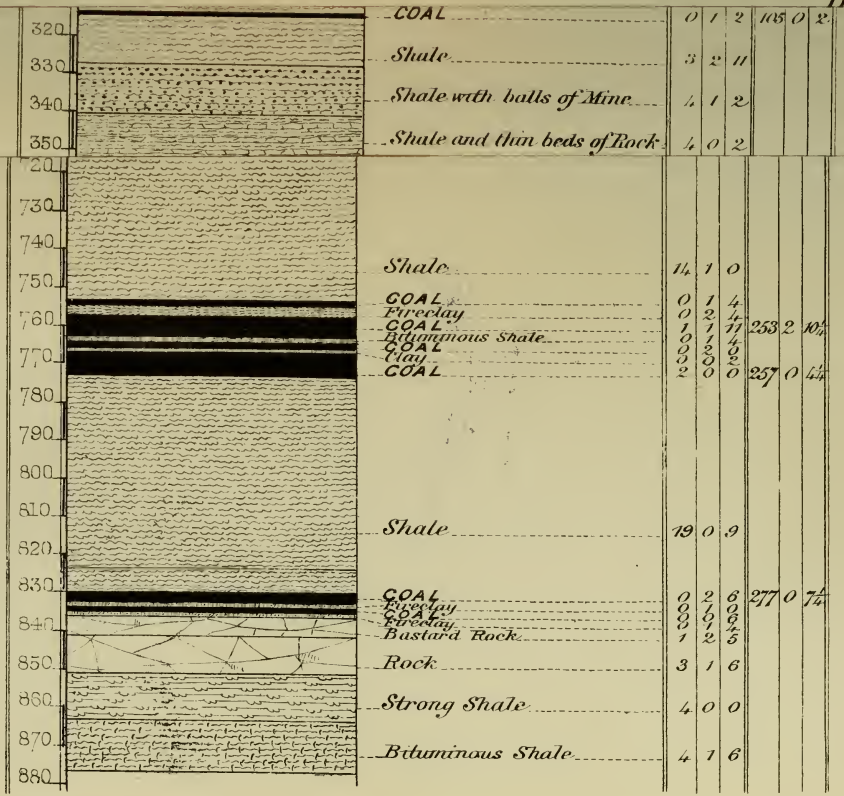
A.Reid, Newcastle on Tyne.

VERTICAL SECTION
OF THE
SOUTH CROP MEASURES,
Accompanying Mr George Birbecks Paper
on the
BRYNCETHIN, LLANGEINOR & OGMORE VALLEY, MINERAL DISTRICT.

Scale 1 Inch = 100 Feet

Feet		Thicknesses Coal Ft	In	Ironstone Ft	In	Fireclay Ft	In
0	COAL (Little Bettws Seam)		4	0			
66							
198							
264							
330							
396							
462							
594	Rock						
860							
923	COAL (Penbryn) Fireclay		4	9			
	Rock						
	Argillaceous Shale						
782							
836							
924							
990	Rock						
1056	Blackband Ironstone Argillaceous Shale				2	3	
1122							
1188							
1254	Rock						
1320	Oil Doidy COAL		2	8			
1386							
1454							
1518							
1584							
1650							
1716							
1782	Rock						
1848	COAL (Malthouse Vein) Fireclay		4	0			
1914							
1980	Rock						
	COAL (Rock Vach Vein)		2	0			
2046							
2112	Rock						
	COAL (Rock Fawr Vein) Fireclay		4	0		3	0
2178							
2244							
	Rock						
2310	COAL (Small Vein)		1	0			
	Rock						
2373	COAL (Double Vein)		3	0			
2442							
2508							
2574							
	Rock						
2640							
2706							
	Argillaceous Shale						
	COAL (Small Vein)		1	6			
2772							
	Rock						
2838							
2904							
	Argillaceous Shale						
2970	COAL (Bridge Vein)		3	0			
3036							
	Argillaceous Shale						
3102							
	COAL (Eastern Vein) Fireclay		5	0		2	6
3168							
	Argillaceous Shale						
	Courses of Ironstone						
3234	Argillaceous Shale						
	Rock						
	Argillaceous Shale						
3300	COAL (Boddyr Fach) Fireclay		2	0			
	Ironstone Argillaceous Shale				0	3	3 0
	Courses of Ironstone						
3366							
	Argillaceous Shale						
3432	COAL (Boddyr Fawr) Fireclay		3	0			4 0
	Argillaceous Shale						
	COAL (Sooty Vein) Fireclay		5	6			
	Argillaceous Shale		2	0			
3498	COAL						
	Ironstone				1	0	
	Ironstone				1	3	
	Argillaceous Shale						
	Tin Pan Ironstone				0	9	
3564	COAL (North Fawr) Fireclay		15	0			4 0
	Sandstone Rock						
	COAL (South Fawr) Fireclay		4	0			3 0
	Argillaceous Shale		3	0			
3630	COAL (Central Vein) Fireclay						4 0
	Argillaceous Shale						
	Balls and Pins of Ironstone				3	0	
	Argillaceous Shale						
	COAL (Yard Vein) Fireclay		5	6			2 6
3696	Argillaceous Shale						
	COAL (Slaty)		2	0			
	Pins of Ironstone				0	3	
	COAL (Six Feet Vein) Fireclay		5	9			2 6
3762							
	Argillaceous Shale						
	Pins and Balls of Ironstone						
	COAL (South Nine Feet Vein) Fireclay		9	0			3 0
	Pins and Balls of Ironstone				0	10	
3828	Argillaceous Shale						
	Pins and Balls of Ironstone				0	7	
	COAL (Every Vein) Fireclay		4	0			
	Balls of Ironstone				0	5	3 0
	COAL (Rider Vein)		1	0			
3894	Courses and Balls of Ironstone				0	9	
	Sandstone Rock						
	COAL (Five Quarters Vein) Fireclay		5	6			2 6
	Sandstone Rock						
3960	COAL (Gribbur Fawr) Fireclay		6	0			2 6
	Courses of Ironstone				3	8	
4026	Argillaceous Shale						
	COAL (Garnet)		0	3			
	Pins of Ironstone				0	2	
	Nine Inch Ironstone				0	6	
	Sandstone Rock						
4092	Courses of Ironstone				2	4½	
	Sandstone Rock						
	Courses of Ironstone				1	10	
	COAL (Gribbur Fach)		3	0			
4158	Sandstone Rock						
	Pins of Ironstone				0	4	
	Sandstone Rock						
4224							
	Argillaceous Shale						
4290	Pins and Balls of Ironstone				0	8	
4356							
	Argillaceous Shale						
4422							
4488	Pins and Balls of Ironstone						
4554							
4620							
	Argillaceous Shale						
4686							
4752	Millstone Grit						
4818							
4884							
	Sandstone Rock						
4950							
5016							
5082	Grey Sandstone						
	COAL (Crows Foot Vein)		2	0			
		118	5	17	7½	39	6

A. Reid, Newcastle on Tyne.



COAL	0	1	2	105	0	2
Shale	3	2	11			
Shale with balls of Mine	4	1	2			
Shale and thin beds of Rock	4	0	2			
Shale	14	1	0			
COAL	0	1	4			
Fireclay	0	2	4			
COAL	1	1	11	253	2	10½
Bituminous Shale	0	1	4			
COAL	0	2	0			
Clay	0	0	2			
COAL	2	0	0	257	0	4½
Shale	19	0	9			
COAL	0	2	6	277	0	7½
Fireclay	0	1	0			
COAL	0	1	6			
Fireclay	0	1	4			
Bastard Rock	1	2	5			
Rock	3	1	6			
Strong Shale	4	0	0			
Bituminous Shale	4	1	6			

(Proceedings S.W. Inst. Engs: 1876) N°1. Vol 10.

A. Reid, Newcastle on Tyne

VERTICAL SECTION

OF THE

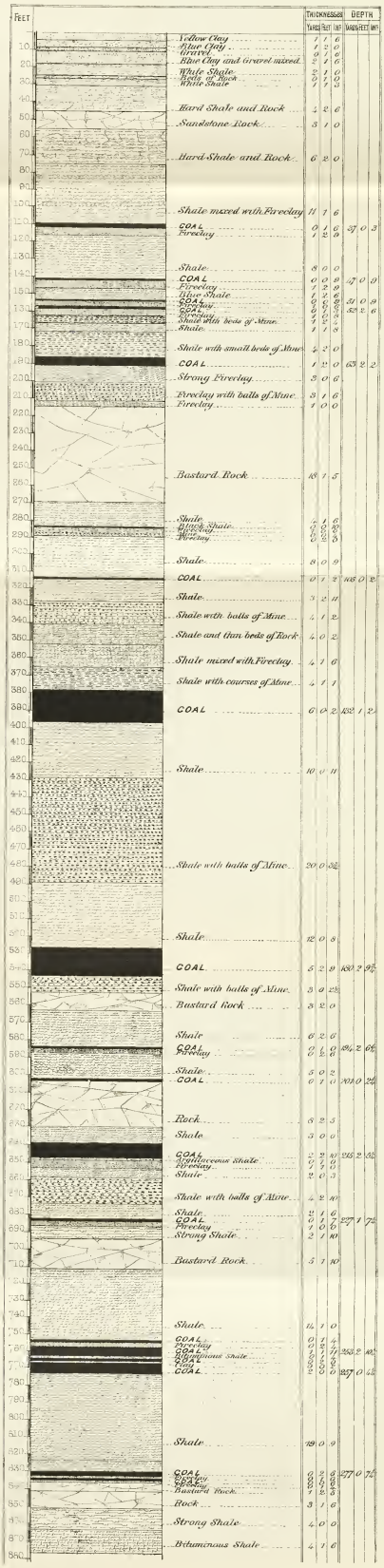
BARROW PIT BRYNCETHIN,

Accompanying Mr. George Birbeck's Paper

on the

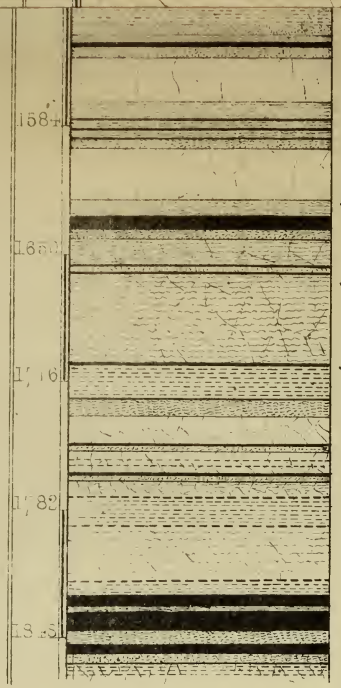
BRYNCETHIN, LLANGEINOR & OGMORE VALLEY MINERAL DISTRICT.

Scale 1.50 Feet to 1 Inch.



(Proceedings S. W. Inst. Engrs. 1876) No. 1. Vol. 10.

A. Reid, Newcastle on Tyne



Shale with bands of Mine							
COAL		0	0	3			
Shale	Fireclay	1	1	5			
COAL		0	2	4	513	1	0
	Fireclay	1	1	4			
Rock							
	Shale						
COAL	Shale	0	0	9			
COAL	Shale	0	0	3			
COAL		0	0	2			
	Fireclay	1	1	7			
Rock							
	Shale						
COAL	(Two Feet Nine)	1	1	11	545	0	0
	Fireclay	1	0	2			
COAL	and Stone	0	1	2			
Rock and Shale							
COAL	Slashes	0	0	6			
COAL		0	0	3			
Rock and Shale							
COAL		0	1	6			
	Mineground						
COAL		0	0	11			
	Fireclay	2	2	4			
Rock							
COAL		0	1	1			
	Fireclay	1	0	3			
Rock and Mineground							
COAL		0	1	9			
Rock & Shale	Fireclay	1	0	2			
	Ironstone	0	0	3			
Mineground	& Blackband	4	2	7			
	Ironstone	0	0	3			
Shale and Rock							
	Ironstone	0	0	3			
	Mineground	2	0	0			
COAL	(Four Feet)	2	0	6			
	Clod						
COAL	(Six Feet)	3	0	0	615	1	0
	Fireclay	1	2	6			
COAL		1	2	10	616	2	0
	Fireclay and Rock	1	1	4			
Rock and Mineground							

A. Reid, Newcastle on Tyne

VERTICAL SECTION

— OF THE —

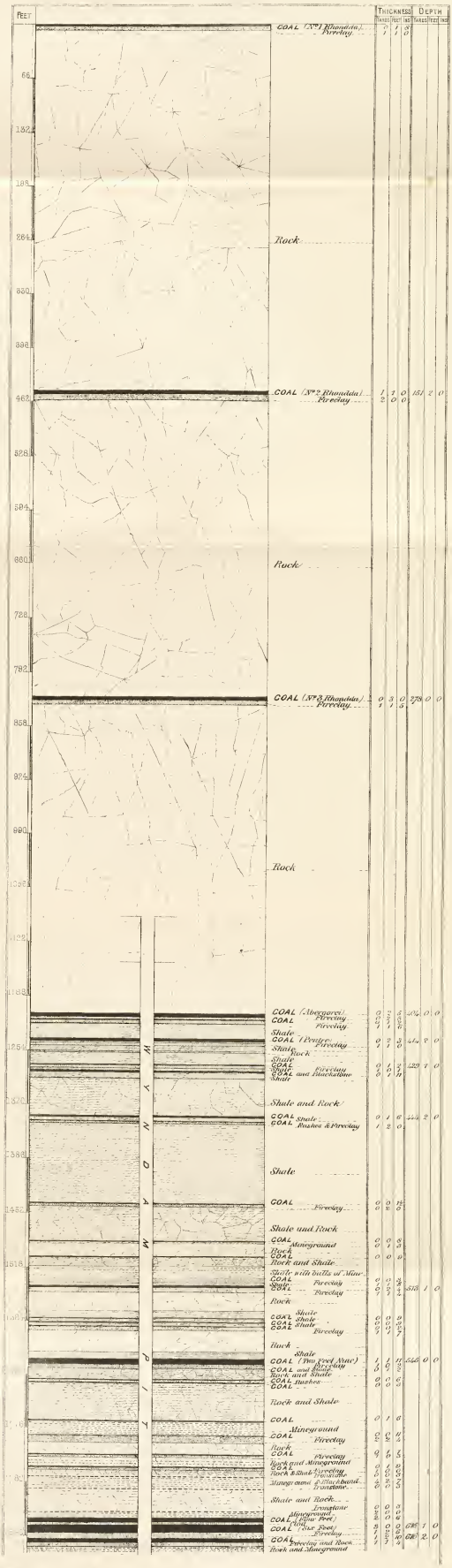
OGMORE VALLEY & LLANGEINOR MEASURES,

Accompanying Mr George Birbeck's Paper

— *on the* —

BRYNCETHIN, LLANGEINOR & OGMORE VALLEY, MINERAL DISTRICT.

Scale 100 Feet to 1 Inch


FEET
66
132
198
264
330
396
462
528
594
660
726
792
858
924
990
1056
1122
1188
1254
1320
1386
1452
1518
1584
1650
1716
1782
1848
Rock
Rock
Rock
Shale and Rock
Shale
Rock
Rock and Shale
Rock
Rock and Shale
Rock and Shale
Rock and Shale
Shale and Rock
Shale
Rock and Shale
Shale and Rock
Rock and Minegrund
Rock and Minegrund
Shale and Rock
Rock and Minegrund
Rock
Rock and Shale
Rock and Minegrund
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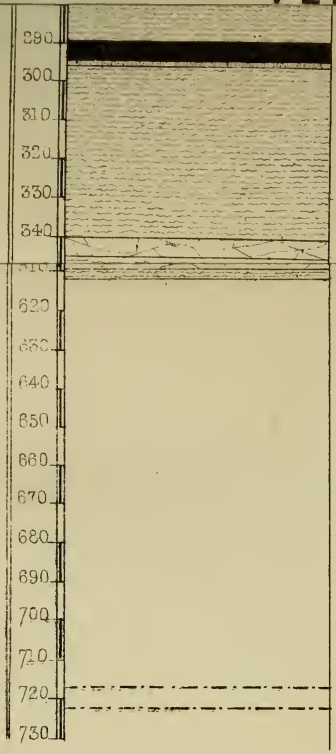
Rock and Minegrund
Shale and Rock

VERTICAL SECTION



Shale	3	1	9				
COAL (3rd South Vein)	1	2	0	38	1	5	
Soft Fireclay	0	1	0				
Shale	14	2	6				
Rocky Ground	1	2	0				
Strong Shale	0	2	0				
Fault struck at Bottom of Pit							
Position of Cribbur Fawr if undisturbed							

Proceedings S.W. Inst. Engs. 1876) N°1. Vol. 10

A. Reid, Newcastle on Tyne

VERTICAL SECTION

OF THE

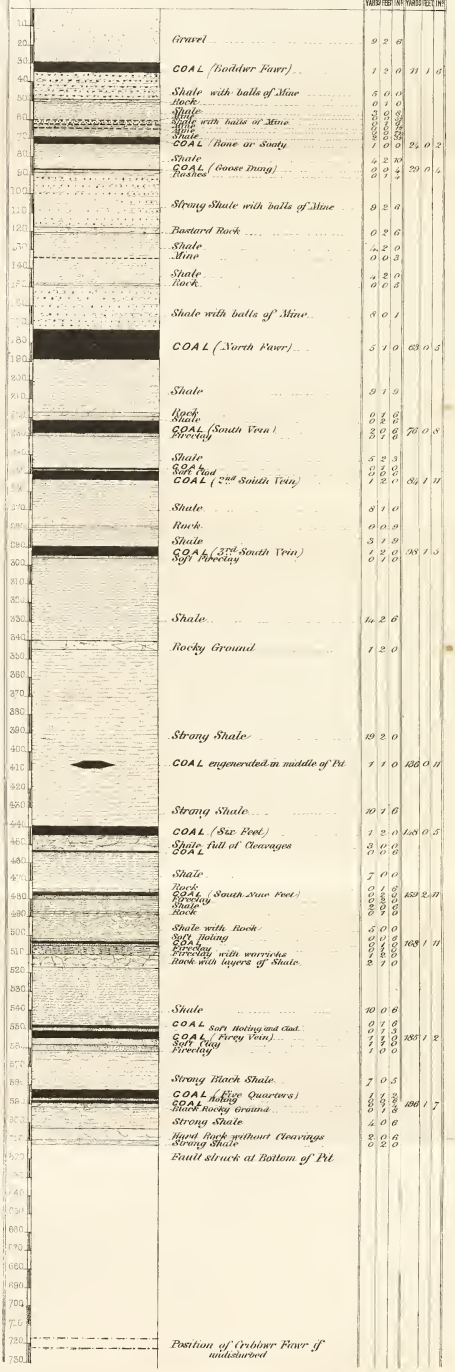
YNYSAWDRE PIT,

Accompanying Mr George Birbeck's Paper

on the

BRYNCETHIN, LLANGEINOR & OGMORE VALLEY, MINERAL DISTRICT.

Scale 50 Feet to 1 Inch


FEET
THICKNESSES
YARDS FEET INS
DEPTH
YARDS FEET INS
Gravel 9 2 6
COAL (Bodduer Fawr) 1 2 0 71 1 6
Shale with balls of Mine 5 0 0
Rock 0 1 6
Shale 2 2 0
Balls with balls of Mine 0 2 6
Shale 3 2 0
Shale 0 2 22
COAL (Bone or Shaty 1 0 0 24 0 2
Shale 4 2 20
COAL (Goose Dung) 0 0 4 29 0 4
Rashes 0 2 7
Strong Shale with balls of Mine 9 2 0
Bastard Rock 0 2 6
Shale 4 2 0
Mine 0 0 3
Shale 4 2 0
Rock 0 0 6
Shale with balls of Mine 6 0 1
COAL (North Fawr) 5 1 0 63 0 5
Shale 9 1 9
Rock 0 2 6
Shale 0 2 0
COAL (South Vein) 2 0 6 76 0 8
Firestly 5 1 6
Shale 5 2 3
COAL 0 1 0
Soft Rod 0 0 6
COAL (2nd South Vein) 1 2 0 84 1 11
Shale 6 1 0
Rock 0 0 2
Shale 5 1 9
COAL (3rd South Vein) 1 2 0 98 1 5
Soft Firestly 0 1 0
Shale 14 2 6
Rocky Ground 1 2 0
Strong Shale 19 2 0
COAL engenerated in middle of Pit 1 1 0 136 0 11
Strong Shale 10 1 6
COAL (Six Feet) 1 2 0 148 0 5
Shale full of Cleavages 0 0 6
COAL 0 0 6
Shale 7 0 0
Rock 0 0 6
COAL (South Nine Feet) 0 1 6 157 2 11
Firestly 0 2 0
Shale 2 0 0
Rock 0 1 0
Shale with Rock 5 0 0
Soft Holing 0 0 6
COAL 0 1 6 168 1 11
Firestly 0 2 0
Firestly with worricks 1 1 0
Rock with layers of Shale 3 1 0
Shale 10 0 6
COAL Soft Holing and Clod 0 1 6
COAL (Firey Vein) 1 1 3 185 1 2
Soft Clod 1 1 0
Firestly 1 0 0
Strong Black Shale 7 0 5
COAL (Five Quarters) 1 1 0
COAL Holing 0 0 3 186 1 7
Shale Rocky Ground 0 1 3
Strong Shale 4 0 6
Hard Rock without Clearings 2 0 6
Strong Shale 0 2 0
Fault struck at Bottom of Pit
Position of Grubber Fawr if undisturbed

A. Reid Newcastle on Tyne

been most successfully substituted; and the ruling idea still seemed to be to increase the ventilating power, as the pits became crowded with men and machinery, especially where steam had to be used underground. At Bwllfa Colliery, where steam was sent down the downcast pit, it had been found necessary to work the ventilator faster and supply a larger quantity of air, more especially so when the external temperature was against the ventilator; so that they were driven from the furnace system, not only as regarded safety, but also as regarded economy (except in very deep pits), to the use of mechanical ventilation.

Mr. A. J. Stevens said that although the question whether the large or smaller shaft should be the upcast was not new, still it was a matter of much interest. He had constructed a small model, made of two tin tubes, one being a quarter of an inch and the other half an inch in diameter, of equal length, and connected at base; he tried it over and over again, and every time the upcast was distinctly the largest. He reversed the current, and it immediately reversed itself and ascended the largest tube or shaft. That seemed to confirm the fact that the smaller shaft always became the upcast, because in the conditions under which he made the experiment the surrounding air was at a lower temperature; but, from the greater surface of the smaller shaft exposed, the air was cooled more in that than in the larger one, and consequently the latter became the upcast. Air obeyed the laws of every other fluid, and a very small difference in the temperature would cause an ascending current.

Mr. Thos. Jones Price said that, as the President had remarked, the standpoint from which natural ventilation derived its interest at the present day was its influence upon mechanical ventilation, and that was not inconsiderable, when it was remembered that explosions had been attributed to variations in temperature by scientific men who had made the subject their study. It was, therefore, most desirable that the extent of that influence should be defined. Mr. Galloway had given a forcible illustration where he showed that, under three different tempera-

tures in the downcast, the conditions in the upcast continuing constant, the effective duty demanded of the ventilating power to produce the same current of air through the colliery varied in the ratios of 7, 15, and 23. Now, it would be convenient if the extent of that influence could be generally defined, and it might probably be expressed in tables, instead of employing a complex formula. No doubt the test of safety would lie in an examination of the volume of air by the anemometer, and of the condition of the return current, but the tables would be interesting and instructive, and might suggest the propriety of having in reserve for extreme cases an auxiliary to the usual ventilating power.

Mr. Henry K. Jordan observed that the Author stated that the best proportions of the upcast to the downcast should be one-third of the downcast, and Mr. Wilkinson had said he agreed with the Author; but he would ask whether it would be wise or prudent to adopt that conclusion, and only make the upcast one-third the area of the downcast.

Mr. Wilkinson thought that was an error; the upcast should be one-third less than the downcast, and not one-third of it.

Mr. Geo. Jee had put a question to Mr. Wilkinson at the last meeting, whether it was his invariable experience that the smaller shaft became the upcast. To his mind there could be no reason why one should become the upcast more than the other, unless there was a difference of temperature, because he was quite certain that if the air were of the same temperature in both shafts it would balance, and it would be contrary to all the known laws of physics if such were not the case. He was quite prepared to agree with Mr. Wilkinson in that he had observed the smaller shaft became the upcast, but that it probably arose from a slight variation of temperature—say, of one or two degrees, which would make a great difference, and generate a current of from 1,000 to 1,500 feet in a shaft of 75 feet area.

Mr. Begg was not aware that he had quoted Mr. Wilkinson advocating that the upcast should only be one-third of the area of the downcast. He had said at page 92, Vol. X., paragraph 2:

"The fact remains that the smaller shaft becomes the upcast, "and a gentleman of experience such as Mr. Wilkinson had no "doubt about it; and it is an axiom of ventilation with them that "a proper proportion should be maintained between the upcast "and the downcast shafts." He did not lay down any rule as to the proportions of the upcast and downcast, and the object of his Paper was to afford an opportunity for the discussion of the question of natural ventilation, so that they might arrive at some conclusion.

He had also stated at page 96, Vol. X., that at the Glasgow School of Mines it was thought necessary to have a rule of proportion between the shafts, and that the smaller should be one-third less in area than the larger or downcast, and that was greater than practised at the Oaks Colliery. He did not lay that down as his theory, but only referred to what they had been taught. He concurred in the view that the practical benefit from his Paper was in what Mr. Price had said, and that whatever motive power was adopted to produce ventilation, it would be of much importance to its effectual working that the proper proportion between the upcast and downcast shaft, so far as it affected the natural ventilation, should be established; and he thought that tables such as those referred to by Mr. Price would be useful for reference.

Mr. Thos. Jones Price did not think that Mr. Begg had quite understood him; what he had meant to say was that natural ventilation under certain conditions seemed to retard mechanical ventilation, and if they could get the influences thus shown put into the shape of a formula, or table, it would be of much service.

A vote of thanks was accorded to Mr. Begg for his Paper.

Discussion on "Coal Washing."

The President said that the next Paper for discussion was one on "Coal Washing," written by himself; and he did not

know that he could say much on the subject beyond what was contained in the Paper itself in pointing out the value of pure material, which was perhaps not so thoroughly put forward as it might have been; and he would also draw attention to the several experiments which might be made as to the density of the coke. Probably some gentlemen who have been making coke with washed coal might be able to speak as to the density of the coke they have produced, because that was a point that affected the sales value, especially for exportation. Mr. Sheppard had kindly brought a model of his coal washer for their inspection; and those gentlemen who were at Wigan last summer would have seen the trough washing apparatus, referred to in his Paper, at work at Ince Hall. In that process the coal was first raised on to the screen, the small passing through into a hopper, from which it was carried away by the water, by a simple arrangement, along the washing troughs, in which are inserted at intervals, as described, a number of boards or stops, at the back of which the dirt accumulated, and was let out through a false bottom, and the washed coal carried forward over the stops into the trams. That process separated the dirt to some extent, but not thoroughly, although sufficiently so for some purposes in that district; but where it was necessary to compete with best coke in the market, as they had to do—for the first thing that drew their attention to coal washing was the fact that they were obliged to displace Brancepeth coke—it was better to resort to the coal washing machine on the principle of the ordinary jigging machines, by which the coal floated away, while the heavier material sank down into the lower bash. Mr. Sheppard's machine was on the same principle. The coal was brought up from the wagons by elevating buckets and passed over suitable screens to size it, the different sizes being washed separately; it then passed into supply hoppers, and from thence, by a regulating door, on to the washing bash or sieve, where it was washed or jigged by the action of a plunger giving an intermittent action to the water, by which the coal floated over, whilst the shale accu-

mulated at the bottom, and was taken away by a worm to elevating buckets, which discharged it into the refuse tram. The clean coal was also carried over to another series of elevating buckets, which discharged it into the coal wagons. By that method of washing the necessity of using a large quantity of water, which caused a considerable waste of coal and pollution of the rivers, had been overcome, and the same water was now used over and over again, and the fine coal was not carried away to waste.

The operation might be seen more clearly from the model of the machine than from the drawings. The machine performed its work as satisfactorily as he thought it was possible to get steam machine washing. It had also the advantage in being able to wash small coal after passing through the rollers for crushing, and it was found that crushed coal thus produced a more solid and better quality coke. Besides which the value of the coal annually saved, and which previously was wasted, was something serious. It made a difference to them of about £4,000 per annum upon each furnace, which represented the difference between using coke with ten per cent. of dirt and being able to remove a great part of that by using crushed coal in the washing machine. He might also refer to another machine on the same principle for washing coke or breeze, which he thought would perform a duty which had not been done before. They had in the manufacture of their coke a quantity of small breeze, which had been tipped and carted away for burning lime and making streets, and an immense amount of waste had been caused in that way; whereas when the breeze was washed and purified the small coke was just as good as the large for certain purposes.

Mr. Thos. Jones Price regarded the due separation of the coals into different classes, according to size, as one of the essentials of satisfactory washing. The President spoke of three divisions, but practically of four, as the dust coal was first separated and not washed. Recent machines had two divisions

only, and the speaker would like to have an expression of opinion from the President as to the minimum number of classes or divisions for producing the more satisfactory results. The next point was that of crushing or grinding the coal. The paper mentioned that coke made from ground coal was more dense, and certainly the finer the coal the greater the cohesive power of the coke. The question then arose, at what stage should the grinding be effected? If it were effected before the washing, as the coal could not be crushed without also grinding the shale, they would afterwards have to deal in washing with finely comminuted shale—the very thing they wished to avoid. On the other hand, some coals contained pyrites; and if the grinding were effected after the washing, the pyrites must pass to the coke ovens. He observed that the Paper dealt with the difficulty by a compromise—crushing the coal before washing through a $\frac{3}{4}$-gauge, and not grinding it fine; and he would ask the Author how far he had succeeded in avoiding over-disintegration of the shale and at the same time in reducing the coal fine enough for dense coke?

The Author stated, at page 122, No. 3, Vol. X., that "the purest coal was conveyed to the greatest distance." The speaker did not clearly apprehend the meaning of that, for at page 130 it was stated "that the coal left in catch pool contained 10·13 per cent. of ash;" and it was a matter of observation that the coals deposited in the furthest catch ponds were most associated with foreign matter. The statements made by the Author at pages 130 and 131, that the coal carried away by the effluent water contained from 25 to 29 per cent. of ash, showed that he could not mean that the coal carried furthest by the water was the cleanest in bulk. As to using the water over and over again, he thought there could be no question that it should not be allowed to escape and pollute the brooks; but whether it should be continuously used without an interval for settling may be questioned. He would, for the purpose of illustrating the effect, take a hypothetical case, and would assume that the dirt

extracted by an ordinary washing machine was 10 per cent. of the unwashed coal, and that the coal deposited in the catch ponds was another 10 per cent., and contained 10 per cent. of dirt. Then, first, he would pass 100 tons of coal through the machine, allowing the water time to deposit before using it again; he would thus have 10 tons of dirt extracted by the machine, 10 tons of deposit in the catch ponds, and 80 tons of clean-washed coal. Again, he would pass 100 tons of similar coal through the same machine, using the water over again, without an interval for settling; he would then, as before, get 10 tons of dirt extracted by the machine, and 90 tons of so-called washed coal, or an increase in weight of $12\frac{1}{2}$ per cent.; but of these 90 tons, 10 tons were what would in the former case have been deposited in the catch ponds, and contained 10 per per cent. of dirt; so that what was got was 80 tons of clean-washed coal, plus 9 tons of clean-washed coal, plus 1 ton of dirt, or an increase of $\frac{1}{90}$th part of the gross weight in dirt, which amounted in the resulting coke to an additional $1\frac{2}{3}$ per cent. of ash. He wished to ask the opinion of the President how far he thought it was prudent to pursue a method by which an increase of $12\frac{1}{2}$ per cent. was gained in the yield of the coal, at the cost of an increase of $1\frac{2}{3}$ per cent. in the ash of the coke.

In conclusion, he begged to inquire of the President—

1st. The number of classes his experience led him to recommend that the coal should be divided into, prior to washing?

2nd. Whether in his judgment crushing the coal to a $\frac{3}{4}$-inch gauge prior to washing satisfied the exigencies of washing, and of producing the densest and best coke?

3rd. His opinion as to the expediency of continuously using the same water over again, without an interval for settling, thereby increasing the yield in weight, at the cost of an increase in the percentage of ash?

Mr. SHEPPARD thought that Mr. Price had misapprehended

what the President meant when he said that there was an increase of 10 per cent., for it must be remembered that the deposit of fine coal was not more than about $7\frac{1}{2}$ per cent. and not 10 per cent.

Mr. Thomas Jones Price: That he assumed for illustration, and he said that in dealing with 100 tons of unwashed coal, 10 tons of dirt were obtained; and if an interval were allowed for the water to settle, then 10 per cent. of fine coal was deposited in the catch ponds, containing 10 per cent. of dirt, and 80 per cent. of clean-washed coal was obtained. But if the water were not allowed to settle, then 90 tons of washed coal were obtained, viz. 80 tons of clean-washed coal, together with the 10 tons that would otherwise have been deposited in the catch ponds, and which contained 10 per cent. of dirt.

The President said he would explain, perhaps, the question of the settling. In the case referred to there was only one pond, which was in use at the time, and therefore there was no opportunity of testing what was carried to the furthest distance; but it was perfectly true that the finest coal would be carried to the greatest distance, and also the finest dirt, not in consequence of the difference in the specific gravity of the coal and shale, for the shale would be separated earlier, unless the specific gravities were the same; and that which was in suspension longest would be the lightest material, the purest fuel.

Mr. Thomas Jones Price said that it depended partly on that, no doubt, but the separation was effected by the resultant of two forces: the one being that of gravitation, and the total influence of that on any given particle would depend on its specific gravity, and also on its volume, which was a magnitude of three dimensions; the other force was that given out by the current of water, and would depend in part on the velocity of the current, and also in part on the surface of the particle exposed to its action; and as surface had but two dimensions, the influence of the current of water was relatively much greater on small particles than on large ones, so much so that a higher specific gravity will not in many cases counteract it; that was clearly

shown by the President's statement that the coal carried away by the effluent water was so carried in company with 25 per cent. of its weight of shale.

The PRESIDENT: In that case it was so, but if the water had free course to carry away the deposit as along a river, it would, he thought, be found that that deposited at the greatest distance was the purest coal.

Then, as to the question of the difference in the size for washing so as to obtain the best results, the coal was more easily dealt with in washing when separated into three different sizes, and was also more available for consumption. The washed nuts were found to be very good for all purposes, whereas the dust coal was better dealt with in washing by itself. He thought three sizes were the most convenient for all purposes. It would doubtless be better to grind the clean coal after the separation of the shale, and he thought that would be an improvement.

Mr. THOMAS JONES PRICE said that in some recent experiments at Ynysawdre he observed that that had been done. He would remind the President that he had not expressed an opinion as to how far it was advantageous to gain in the yield of coke at the expense of increase of ash.

The PRESIDENT thought it was better to have the purest fuel, but he did not think the theory put forward by Mr. Price was correct, particularly as the density and purity of the coke was better in result by the improved system of washing and using the water over again.

Mr. THOMAS JONES PRICE asked whether he was to understand that the coke was improved by the addition of the 10 per cent. from the catch pond.

The PRESIDENT did not think that was the point, but that the question was by which apparatus the dirt was most effectually separated from the coal.

Mr. THOS. JONES PRICE said he did not altogether agree to that, for it was evident, he thought, that where in one case by allowing the water to settle in catch ponds some 10 per cent. of

fine coal was obtained, which was mixed with 10 per cent. of dirt, in the other case, by using the water over again, that 10 per cent. was carried over with the washed coal, giving the resulting coke a higher percentage of ash.

Mr. SHEPPARD remarked that as the water flowed over and passed into the receptacle a partial settlement took place, and the dirt was deposited and discharged by the refuse elevators.

The PRESIDENT said that the actual fact, however, was that the improved machine washed the coal better than the other. They had had a great deal of experience with the ordinary washing machine, and he had no doubt the coal was frequently passed through more rapidly than it should have been, in consequence of the large quantity passed over. The value of Mr. Sheppard's improved machine was in doing a certain quantity of work, and doing it thoroughly, and in the utilisation of the water in using it over and over again.

A vote of thanks was accorded to the President for his valuable Paper, and the discussion adjourned to the next meeting.

The discussion of Mr. George John Jee's Paper on "The Cwm Carn Reservoir" was adjourned to the next meeting.

The following Paper by Mr. George Wilkinson on "Personal Experiences in Tubbing Shafts, and other Colliery Work" was taken as read, and ordered to be printed.

A vote of thanks to the President closed the proceedings.

ON

PERSONAL EXPERIENCES IN TUBBING SHAFTS, AND OTHER COLLIERY WORK.

By Mr. Geo. Wilkinson.

LINING AND TUBBING FOR PITS.

In the first pit that the Writer had to sink, about 50 yards of cast-iron Tubbing were put in to keep back the surface water. As soon as the pit had been sunk to the solid, a foundation was cut quite level in the solid ground around the pit to receive the Tubbing; a piece of flannel soaked in Stockholm tar was first laid upon the foundation so cut out, and on that was placed a cast-iron wedging curb, which was then securely wedged up as tightly as possible so as to line with the centre of the pit. A strip of deal, about half an inch thick (for the purpose of subsequent wedging), was then placed upon the wedging curb, with the grain of the wood showing towards the centre of the pit, and upon that was placed the first length of Tubbing plates, with strips of wood also placed up the joints for subsequent wedging. That process was repeated length by length of Tubbing all round the pit, until it was all put in, the back of the Tubbing being securely rammed with ashes or dry rubbish. The plug holes in the centre of each Tubbing plate should be left out until the top or last segment of the Tubbing had been completed, when the holes must be gradually filled up with wooden plugs tier by tier from the bottom, and every joint of the Tubbing

wedged up as securely as possible by driving in thin dry wooden wedges into the parting strips until no more can be driven, by which means the water would be securely dammed back, and its pressure brought against the Tubbing.

By that method they succeeded in stopping back the water, the pressure of which was, however, only 70 to 80 lbs. to the square inch. The bottom segments of the Tubbing were 4 feet long and 2 feet high, and $1\frac{1}{4}$ inch in thickness, which was reduced at the top to $\frac{7}{8}$ths of an inch. Had the pressure of water been greater, then the Tubbing should have been made of a proportionate thickness; and segments of Tubbing to resist a heavy pressure should not be more than 4 feet in length and 18 inches in height; whilst a segment of 1 foot high would, he thought, resist any pressure of water.

In another pit the Writer was engaged with two others in sinking it at so much per fathom. The ground in that pit was strong clay and sand to the depth of 30 feet. At the depth of 9 feet a wooden curb was fixed around the pit, one also being placed on the top, and the pit was lined with 1-inch deal boards from curb to curb, the lining being strengthened by placing other curbs, 2 feet apart, inside the boards between the top and bottom curbs. The pit being thus secured, sinking was recommenced until the solid strata was reached, the operation of putting in successive lengths of curbs and lining going on regularly as the pit increased in depth.

If the pit were damp, and no furnace at the bottom to cause any heat, the above method of lining would last for a number of years; but, under the present law, the Inspectors would not allow that method of sinking.

In another pit that he sunk there were 65 feet of soft clay, stones, water, and sand, before the solid was reached. The pit was commenced with a diameter of 14 feet 8 inches, but when finished had been reduced to 8 feet. After sinking about 9 feet, a curb was put in at the top and one at the bottom, with backing deals behind the curbs, properly secured with wedges and

strengthened with other curbs placed every 2 feet apart. Three or four of these lengths had been put in, when the ground became so soft and full of sand and water that great difficulty was experienced in getting in a 3-feet length; but by steady perseverance the solid was at length reached at a depth of 65 feet, when they proceeded to strengthen the lining by putting in a curb between every one that had been placed before, and that was done because it was found that the top of the pit was giving way.

After that they had some 20 feet of quicksand, with a very large quantity of water, to contend with; and to overcome that difficulty they laid down a strong 10-inch "drifting curb," made of oak, securely bolted across the joints, and drove down planks 21 feet long, 7 inches wide, and 3 inches thick, in a slanting direction at the back of the "drifting curb," all round the pit, the edges of the planks being bevelled to answer the circle.

Within 3 feet of the top of the planks another curb was set so as to keep them in their places. The planks were first driven down as sheet piles about 18 inches, after which sinking was recommenced, and the sand and water filled out until the bottom of the pit came about 9 inches below the "drifting curb," when that curb was driven down the 9 inches on to the bottom of the pit, and the sheet piling then driven down 9 inches more below the "drifting curb," and the sand and water filled away as before another 9 inches; and by repeating that process the quicksand was passed through and the solid again reached.

The pit was then walled up with dressed freestone, the bottom course being in segments of 1 foot in height, and all the joints and beds set in cement; the next course was in segments 18 inches deep by 2 and 3 feet long, and not less than 9 inches in the joints, and set in cement; and that was continued to the top of the pit, the walling being well backed with puddled clay all the way up. The walling, built in that manner, answered the purpose well, for it stopped back all the water and sand; but the size of the pit, as before stated, was reduced to 8 feet in the

clear, the piling and walling having taken up 6 feet 8 inches of the original size.

In the next two pits he had to sink he walled back the water in another way, which he found equal to any of the foregoing processes. They selected the first piece of good strong ground met with in the pit, and at that point levelled off a bed to receive a strong wooden curb, 14 inches wide, in which holes were bored on each side of the pit, to allow a free passage of the water from the back. The curb was set in cement, and on it 14 inches of brickwork, set in cement, was built for a distance of 80 yards up the pit, a space being left on each side of the pit, at the back of the walling, to allow free passage for the water to run down to the holes bored through the curb.

When all the brickwork had thoroughly set, the two holes in the wooden curb were plugged up, which completely stopped back all the water, which then rose at the back of the walling so as to produce a pressure of 130 lbs. per square inch.

He considered that that form of lining for stopping back water was inferior only to cast-iron Tubbing, when the pressure exceeded 100 lbs. per square inch.

REMARKS ON WORKING COAL BY LONG WALL AND PILLAR AND STALL.

In the first twenty years of the Writer's experience the method of working coal was almost exclusively by Pillar and Stall. About twenty-five years ago he was Viewer at a colliery in the North of England, and in one of the districts of that pit the top was very inferior, and the coal very thin; the pit was about 600 yards deep, and whether it was the weight of the strata, or the gas being met with in a highly compressed state, that caused the top to be so bad, he could not at present determine. At that time he was asked to visit Derbyshire to see the Long Wall system, and to ascertain if it could not be introduced into the pit under his charge; after a careful examination he came to the conclusion that it would be advantageous to do so, and

accordingly he took back with him a man accustomed to working in the Long Wall work, and commenced to open out a face of about 80 yards in width. The coal was holed about 3 feet forward every night, and sometimes it would come away by taking out the props, whilst at other times they would have to put in a shot to get it down. It was found under the Long Wall system that the top was much improved, and the coal obtained very much larger, and the system was very extensively carried on at that colliery afterwards.

When the Writer came to South Wales he found all the steam coal collieries that were placed under his charge were worked by the Pillar and Stall system.

After having been a few years in South Wales, he found that in one of the pits they were working the "Four Feet" vein under the mountain, with a cover of about 600 yards of strata to the surface. In that part of the colliery the coal was strong, but it produced a large amount of small coal in working, and the top was very bad, whether from the weight of the strata or the pressure of gas he could not say; but altogether it was so bad that the timbering alone of that district cost thirteenpence per ton, and it was for a time stopped.

He proposed that the Long Wall system of working should be tried at the colliery, but the owner for some time would not consent to make any change. The Writer urged that he was confident the Long Wall system of working would improve the top, but could not speak for certain as to its effect in improving the coal, as he had not, up to that time, had any experience in working the coal in South Wales by the Long Wall system, and was somewhat afraid that, in consequence of there being so many slips in the coal, the pressure on the face would break it up.

Ultimately, however, the Owner brought with him his Consulting Viewer, and consented that a trial should be made with the Long Wall system. Before it was commenced, however, the Writer sketched out what he considered to be the best mode of conducting the work, which was to open out as soon as possible

a face of about 400 yards and work all the coal away, leaving no pillars for the roadways. The Consulting Viewer, however, would not agree to work away all the coal, as he believed that by such a course it would be impracticable to keep the roads open; and his suggestion was that a pillar of about 30 yards should be left on each side of the Level. The Writer objected that, in his opinion, that method would not answer, because it would be impossible to keep the Levels open, and that all the timber that could possibly be put in would not be sufficient to bear the enormous pressure of the top.

The Owner, however, concurred with the Consulting Viewer, and the Writer was instructed to open the workings in accordance with their views. So he commenced by driving cross headings to the rise and to the deep, and left 30 yards of pillar on each side of the Level. That mode of working greatly improved the top, and the coal also worked much larger; but, as he had predicted, the Level could not be kept open as a road, in consequence of the enormous pressure thrown on the pillars; and after continuing some 80 yards he worked off the pillars, and threw it into one face of coal, and the Long Wall work proved a great success; the coal worked large and, comparatively, without any small, and the top was much better and less expensive, so that that experiment demonstrated how important it was to work away all the coal in the Long Wall system.

In his opinion the introduction of the Long Wall system of working into the South Wales Coal Field, had been a decided success, and resulted in a great benefit to the district, by the coal working so very much larger and the top being so much improved, in addition to the saving of expense in timbering, &c.

In strata that produced so much gas as the steam coal measures of South Wales it was of the first importance that, by the Long Wall system, the fresh air was made to travel along the face of the workings, and the goafs were filled with rubbish, so that no space was left for gas to accumulate, which undoubtedly was a great advantage over the Pillar and Stall system. He did

not think that the Long Wall system could be advantageously employed where the coal was strong, and worked large by the Pillar and Stall method in going forward, and the pillars stood well for working back; and this especially applied to those seams with a strong roof and thick, strong coal.

REMARKS ON VENTILATION.

When a Manager finds the ventilation deficient, something must be done at once to improve it. His first step should be to see that the ventilation was passing properly and judiciously around the workings, and if he found that were not the case, he must enlarge some of the roads that required more air, and try to shorten others that can be worked by a lesser quantity, but at the same time should be very careful, when contracting the shorter splits, to increase the quantity in the longer splits, so as not to decrease the total quantity coming into the pit, which he had occasionally seen occur.

There were generally three ways of effecting an increase of the total air current—first, to put up another furnace; second, to build up the stack; and third, to put up a fan. An examination of the bottom of the upcast would decide whether an additional furnace could be put in; and if that cannot be done, then an examination of the foundation of the air stack would decide whether the top of the stack can be raised some 60 feet more; and if that cannot be done, then a fan must be put up.

The first time that the Writer was in difficulty in that way he had at work a steam jet, and could not produce more than about 12,000 cubic feet of air per minute. He proposed to the owner that a furnace should be put up, but that was objected to because it was a pumping pit, and the pump rods would be liable to be burnt; however, as circumstances then permitted no other remedy, and as the ventilation of the pit was not safe when the barometer was low, it was arranged to put the furnace in, but it was found in about twelve months that the pump rods had been all burnt

through, although, fortunately, by that time they had lost all the water and the rods were not required.

Again it was found that more air was required, and another furnace was put up, at a cost of about £500, which gave an additional supply of about 40,000 cubic feet of air per minute; the first furnace gave some 80,000 cubic feet of air per minute, so that a gain of only one-half the quantity of air was effected by the additional furnace, although some persons might have expected to have doubled the quantity by a second furnace; but that could not be so, because the size of the airways and the area of the pit would not allow it, and to obtain double the quantity it would be necessary to also increase the area of the airways.

The next time the Writer was in difficulty for want of an additional supply of air he did the same thing, but found that it did not meet the case, as the circumstances were very different; two pits had been sunk on the side of the mountain, the top of the winding or downcast pit being 40 feet higher than that of the upcast pit, so that a stack of 40 feet had to be built on top of the upcast pit to bring it to a level with the downcast pit, and the rubbish from the winding pit was afterwards tipped in the direction of the upcast, so that in time it filled up the ground all round the upcast pit to the level of the downcast. Up to that time there had been abundant ventilation, but afterwards it frequently happened, when the wind blew from the south-west, that the flames were blown back on to the furnace, and caused a stagnation or check to the ventilation. By putting up a second furnace he had expected to increase the temperature and the quantity of air; but that was not so, and the ventilation was no better, for when strong winds occurred from the same direction the flames were blown back as before, and caused the same defect in the ventilation. At that time there was only one mechanical ventilator in the valley, which on examination he did not approve of; so, instead of putting up a fan, he proposed to the owner to build a stack on the top of the upcast 130 feet high, and which would cost about £500; but as the

old stack finished with 4½-inch brickwork, no addition could be made on it, and consequently the new stack was built around the old one, and when it was completed it was found to answer the purpose exceedingly well, and by keeping one furnace at work only a larger ventilation was procured than by keeping the two going.

At another pit when the air was short he built a stack some 20 feet in height, which answered the required purpose at the time, as it gave 4,000 cubic feet more air per minute, and enabled the works to proceed until a fan was got to work.

At another colliery where the air was deficient a stack was built 60 feet higher than the old one, and produced some 10,000 cubic feet of air more per minute than had been obtained before; and it also caused the furnace to burn four tons more of the best steam coal, so that by raising the stack some 60 feet higher it appeared to be equal to the effect of another furnace underground.

His experience was that a stack 60 feet in height would give more effect on a pit of 200 yards deep than on a pit of 100 yards, but was not prepared to give the reason.

At another pit he moved the furnace from the "Four Feet" down to the "Six Feet," a distance of about 70 feet, and that gave more air than before; but he found that raising the stack 50 feet higher gave much more air than by lowering the furnace a distance of 70 feet, the draft being very much stronger by raising the stack.

In ventilating old workings, or goafs, to the rise, he advised that it was safer not to have the windway at the top of it, but on the lower side, as it was not practicable or wise to ventilate the old goafs if the return be at the top and the fresh air at the lower side, for it will always force the gas through the goaf and send out more than can be contended with; but if the return be at the lower side of the goaf the gas would be kept back by the fresh air, and would not come out in half the quantity that it would if the return be at the upper side of the goaf.

But it may perhaps be said that the goaf would always be charged full of gas; but that was not the fact, for when the barometer was high it would be clear of gas, and when it fell the gas would make its appearance again. And his experience told him that the most effective way to ventilate a goaf was to keep a good airway on the lower side of it. So likewise whenever a blower was met with it was much better to get the fresh air to pass at one side of it, by which means much less gas will exude than when you pass fresh air over it and attempt to sweep it away. As to the colour of the flame of gas, when gas ignited the flame assumed a variety of colours. When there were but 4 volumes of air to 1 of gas it would not explode, but the "top" on the flame in the lamp assumed a light blue colour; when the proportion increased to 5 to 6 volumes of air, the gas would then ignite, and the blue colour became darker; when it reached from 7 to 8 it became a darker blue, and when from 12 to 15 volumes of air to 1 of gas the flame became a very dark blue colour.

When the proportion was 5 to 6 volumes of air to 1 of gas a great number of white spots appeared in the flame; whilst in a long return airway the flame was almost a grey colour, and full of small sparks, which appeared as if caused by coal dust carried with the air igniting at the flame. You will always find those sparks were always seen in the flame if the gas ignited in fresh air, but became much more numerous in the return air, that had a long way to travel; and when the gas ignited in the lamp in a return airway, with a temperature of about 80 degrees, there was hardly any blue colour in the flame; but it was very grey and filled with sparks, and when exploded was weak and did but little damage to the workings, although sufficiently strong to injure people, but very sluggish and weak compared with an explosion occurring in the immediate vicinity of fresh air.

SOME REMARKS UPON THE EXPANSION OF EXPLOSIVE GASES DURING IGNITION.

The Writer had observed that after an explosion in a district that contained about 4,500 cubic feet of gas the fire could not be traced farther than about 400 yards. Taking the 4,500 cubic feet of gas, multiplied by 10 volumes of air to one of gas, there were 45,000 cubic feet of explosive atmosphere, the fire from which, when exploded, did not travel more than 400 yards into the workings, the average area of the passages being some 40 feet.

He remembered a stall containing about 200 cubic feet of gas, which, when it ignited, came back only 30 yards, although three men were burnt very badly on that occasion, the seam being very thin. Put into figures, the 200 cubic feet of gas multiplied by 5 volumes of air would give 1,000 cubic feet of explosive atmosphere, which, on igniting, travelled 1,000 feet and then became extinguished: there was no fresh-air current passing into the stall, so there was only as much air as would cause the gas to ignite.

The explosions were evidently more powerful in fresh air than in foul air, and he found that when an explosion took place in a return airway the amount of flame was not half that resulting from an explosion which took place in fresh air.

On another occasion the gas fired at his candle on the top of a fall, where the roadway had an average area of about 12 feet, the explosion taking place as soon as he entered on the top of the fall and sat down. There were about 600 cubic feet of gas in the cavity in the roof where the fall came from, and the flames went both ways from the fall in one direction against the air current for about 100 yards, and in the other into the workings with the air some 50 yards, making the total distance over which the flames travelled some 150 yards. Now, the 600

cubic feet of gas, multiplied by 12 volumes of air (the area of the place being 12 feet), gave 7,200 cubic feet of explosive atmosphere, which, on ignition, travelled 150 yards along passages having an average area of 20 feet, or a cubic capacity of 9,000 cubic feet more, making in all a total of 16,200 cubic feet of explosive atmosphere for the whole distance travelled.

On several occasions he had seen gas when it would not ignite for want of fresh air, and the flame in the lamp would diminish and go out; and in a very warm return, where the temperature was about 80 degrees, the gas would cause the flame of the lamp to extend to the top of the gauze, but would not ignite or fill the lamp.

His experience had always been that less damage was done at and near the seat of the explosion than at a distance—say, from 300 to 400 yards away. He was convinced that it was of no consequence whether there were 10,000 cubic feet of gas or 100,000 cubic feet that exploded, if it was in one place, for in any case he did not think the force of the explosion would produce any disastrous effect at a greater distance than 500 yards; and he thought that arose from the fact that as soon as the gas ignited the expansive force of the explosion was so great that it drove the fresh air back and prevented its access to the face of the workings, leaving nothing behind but carbonic acid gas.

He did not believe that when an explosion took place the concussion diminished the fire, but that it was extinguished for want of fresh air to support it.

He had known the flames of an explosion to travel 500 yards, and at that distance meet another supply of gas, which exploded and did a great amount of damage, at that point actually blowing the place to pieces; whilst in an opposite direction the same explosion did no harm, because there was no gas to support it, and it soon became extinguished. He also remembered a return airway charged with gas for a distance of some 1,500 yards, which exploded at the furnace and did but very little

damage at the pit bottom and for 200 yards from it; but for the next 400 yards the timber supports were all blown down, whilst for the next 700 to 800 yards its effects were visible by the dust being blown clean off the roadway; and he thought that the reason why no damage was done for the 800 yards was that the gas had not sufficient fresh air mixed with it to ignite, and that also applied to some 300 to 400 acres of gas connected with that return.

It was quite possible, he thought, for the flame of an explosion to travel from 1,500 to 2,000 yards if it had a succession of fresh air and gas to feed it on its course.

The Writer had always thought that the resistance of an explosion must be very great. Suppose a case in which there were, say, 30,000 cubic feet per minute of fresh air travelling an intake at the rate of 8 feet per second: the explosion must have considerable power in it to resist that current and drive the fresh air back.

And on one occasion he noted the effect of that very clearly. He was in a heading, about 300 yards from the place where an explosion had occurred, at the bottom of the upcast shaft; there were four others with him, and they were not more than about 50 yards from the bottom of the downcast shaft when the explosion took place, and neither the men nor himself heard the explosion, because they were then travelling against a current of fresh air of some 30,000 cubic feet per minute; but all at once the whole current of air stopped, and not a movement could be discerned, and from former experience he was certain that an explosion had taken place, and advised everyone to throw himself down with his face to the ground. The flame and force of the explosion reached them in about three seconds, and as they lay on the ground a perfect hurricane, with fire, timbers, bricks, coal, and dust, passed over them.

When an explosion took place its first effect on the air was the same as if a stopping were suddenly built up on the heading,

and the whole current of air was stopped back to the top of the pit, so that the fire afterwards travelled with but little resistance from the stagnant air, although sufficient to feed the fire to some extent.

PROCEEDINGS.

19th July 1877.

The Ordinary General Meeting of the Institute was held at the Royal Hotel, Cardiff, on Thursday the 19th of July, 1877.

Mr. JAMES MURPHY, Assoc. Inst. C.E., Vice-President, in the chair.

The Minutes of the last General Meeting were read and confirmed.

ELECTION OF NEW MEMBERS.

The Chairman announced that the Ballot Lists had been opened by the Scrutineers, and declared the following gentlemen to have been duly elected Members of the Institute, viz.:—

As Members.

Mr. Charles Sheppard, Mechanical Engineer, Ogmore Foundry, Bridgend.

„ Oliver Sheppard, Mechanical Engineer, Ogmore Foundry, Bridgend.

„ Moses George Johnson, Mining Engineer, Norway Villas, Fishponds, near Bristol.

As Graduate.

Mr. Thomas Evans, Junr., Underlooker, Barrow Collieries, Bryncethin, Bridgend.

ADMISSION OF NEW MEMBERS

The following gentlemen, elected at previous meetings, were then formally admitted to the Institute by the CHAIRMAN, and signed the Roll Book, viz. :—

Graduates.

Mr. E. Roger Lewis, Hirwain.
„ Daniel Thomas, Ystrad-Rhondda.

The Discussion of Papers read at previous meetings was then proceeded with.

The further discussion of Mr. Henry K. Jordan's Paper on "The Pencoed, Gilvach-Goch and Mynydd-y-gaer Mineral District," and that of Mr. Birbeck's on "The Ogmore Valley and Tondu Mineral District," was postponed until the next meeting.

ADJOURNED DISCUSSION ON "COAL WASHING."

The CHAIRMAN thought that, after opening the discussion of the President's Paper on "Coal Washing," it would be desirable, in his absence, to adjourn the further discussion until the next meeting, so as to afford him the opportunity of replying to any remarks that might be made, or of bringing forward any new facts.

The subject of coal washing was one of primary importance, considering that coke formed one of the staple trades of the country, and especially where such excellent coal for coke-making existed as in the Ogmore Valley.

Washing the coal was found to increase its value very considerably, and any apparatus to accomplish that purpose economically must possess great interest for the Members of the Institute.

Mr. UPWARD said that, in reference to coke-making, some 18 or 20 years ago he discovered a process by which anthracite coal was converted into a useful fuel. It was done by adding a percentage of pitch to the coal and coking it in the usual way in coke ovens. The specific gravity of that coke was 1·5. Some experiments were made with the coke at the Gadlys Iron Works (if he were not mistaken), and he should be pleased at some future time to give the Institute the results of those experiments. He believed that by using that coke, "No. 2" iron was converted into "No. 1." And there were other advantages in its use, inasmuch as its hardness and density enabled the manufacturer to burden his furnaces to a very much greater extent than he could with soft coke. At a future time he would produce some samples of the coke which were in his possession, and which he had exhibited at the Exhibition of 1862, where it received honourable mention. He had patented the process, and, in conjunction with Messrs. Bethell and Dixon, had built works at Llanelly, where they made the coke for some time.

The CHAIRMAN said that, as a large number of the Members took the greatest interest in the manufacture of coke, the description of any process relating thereto was very valuable, and he hoped Mr. Upward would draw up a short Paper on the subject for the next meeting.

Mr. UPWARD said he should have pleasure in doing so.

Mr. BARROW said that, in reference to the information Mr. Price asked for at the last meeting, he understood him to raise a doubt as to the capability of the machine as altered under the patented arrangements, and that he inferred that the machine retained 10 per cent. of dirt, which, under the old arrangement, was carried away with the water into the settling ponds; he thought, however, that 1 per cent. of the total quantity passing through the machine would represent the whole of the dirt carried into the settling ponds.

Mr. HENRY K. JORDAN said he could not see that Mr. Price was wrong in his deductions; and if Mr. Barrow would refer to the

Proceedings he would find that Mr. Price assumed a certain set of conditions—he did not say they did or did not exist; but assuming it for argument's sake, he said, if he passed 100 tons of coal through the patented machine, the results were 80 tons of clean coal, plus 9 tons of clean coal and 1 ton of dirt, which latter, in the old machines, were deposited in the catch ponds, giving an increase of dirt of $\frac{1}{90}$ of the gross weight, which amounted to $1\frac{2}{3}$ per cent. of ash in the coke. Those were his remarks, and they were incontrovertible if his premises were true. He did not say 10 per cent. was the quantity of dirt got out; but, if his premises were correct, the deduction was correct. No doubt the machine performed excellent duty, and, having seen it at work at one or two places, he had no doubt it would sooner or later come into general use. Whether the machine was capable of improvement, or whether it was a machine which in some respects had disadvantages, was another question. He did not contend that Mr. Sheppard's machine was perfect, and Mr. Price's observations would certainly direct attention to one defect in it, which he had no doubt Mr. Sheppard's skill would enable him to remedy.

Mr. Hort. Huxham quite agreed with the remarks which had fallen from Mr. Jordan respecting the observation made by Mr. Price. He thought it was quite clear that Mr. Price meant to convey that the increase of dirt was 10 per cent. of the 10 per cent. that was, under the old arrangement, deposited in the catch ponds, and not 10 per cent. of the total quantity passed through the machine.

Mr. Sheppard said he did not understand Mr. Price's observations, or what he meant by 10 per cent. of 10 per cent.; whether he alluded to the deposit of rubbish, or to the 10 per cent. of fine coal in the catch ponds. Was he to understand him to say that the rubbish was carried off with the fuel, and not deposited in the settling ponds as under the old arrangements?

Mr. Hort. Huxham said that Mr. Price based his remarks entirely upon previous observations in a Paper read by Mr.

Brogden, some three years ago, upon coke manufacture, in which it was there stated, and set forth in certain tables, that the amount of coal from the washing machine deposited in the catch ponds amounted in some cases to 10 per cent. of the quantity treated, and also that the amount of dirt in that 10 per cent. of fine coal also amounted to 10 per cent.; and, taking that as a basis of his observations, it was clear what his meaning was.

Mr. Henry K. Jordan said that Mr. Sheppard was under a disadvantage in not having read the previous numbers of the Proceedings; but when he did, he would find that the argument was an assumed one, and that it would hold true whatever be the value fixed to the quantity of coal.

Mr. Sheppard said that the great feature of his machine was that there was no change of water, the settling taking place in the machine itself, and not in settling ponds; that was the main point. There were no settling ponds used in connection with his machine, and the settlement of the fine coal and dirt took place in the machine itself. There was no discharge of foul water; the water used was continually going round and round, and not allowed to escape. In any machine where settling ponds or tanks were used, a large deposit of fine coal invariably took place, amounting in some cases to 10 per cent., and in no case to less than $7\frac{1}{2}$ per cent. In the improved machine there were only two discharging outlets, one for coal and one for rubbish. Where the coal was delivered to the machine a man and boy would wash 200 tons a day; the question of labour cost could not be disputed, as it was unquestionably cheaper than any other. The machine might be seen in operation daily at Ynysawdre and the Maesteg Merthyr Collieries without settling ponds, and with settling ponds at the Llynfi Works, and there were also two in Scotland without settling ponds. If any gentleman wished to visit those places, he would be happy to take him and show him the machines in operation, and he had no doubt but that he would be satisfied with the cost and success of washing coal by the improved machine.

Mr. Hort. Huxham inquired whether any experiments had been made with the improved machine to ascertain definitely what proportion of dirt it would extract from any given amount of coal as compared with the work of the old machines?

Mr. Sheppard said that he could only answer that question by asking members to come and see for themselves and examine the coke made from the coal washed by the machine.

Mr. Hort. Huxham said that, although such an invitation was most satisfactory to individual members, it did not bring the information before the Institute, and he had hoped the Writer would have been able to give full and detailed information on that point.

Mr. Sheppard thought that anyone who saw the coke manufactured from the coal washed by the improved machine, must be satisfied that the work was well done, but chemically he could not give the result. Mr. Barrow had one of those machines under his charge for 12 months with settling ponds; the washing was done with the settling ponds, or without them, as he might desire.

Mr. Hort. Huxham said that the purport of his remarks went to mechanical separation only, and not into the chemical question at all.

Mr. Sheppard, referring to the section of the machine, said the coal was carried by the water over the regulating outfall door into the bottom of the settling chamber, in which there was a screw which removed the coal to an elevator, by which it was lifted out in perforated buckets, much in the same way as was done in dredging operations. The coal and water coming into the settling chamber together, the coal settled to the bottom and the water flowed away from the coal, to be used over again. The coal as fed to the machine was deposited in one, or two, or three, chambers or bashes, according to the sizes into which it had been separated. The plunger had valves, so that at the outward stroke it sent off a large quantity of water; but on the return stroke the valves opened, so that the plunger

returned without much disturbing the water, and the coal separated from the water by gravitation, allowing the heavier material to fall to the bottom. The shale and dirt accumulated at the bottom of the bash, and worked its way on an inclined plane to an opening at the end of the bash regulated by a valve, after passing through which the rubbish was carried forward by a screw and afterwards discharged into a waggon by an elevator. The machine was entirely self-acting from beginning to end. The plunger made about 30 strokes per minute, but it was made adjustable to suit the quality of the coal and proportion of dirt in the same.

Mr. J. T. Edmonds inquired what would be considered a long and what a short stroke.

Mr. Sheppard said a short stroke would be 10 inches and a long one 20 inches. An engine with a cylinder of 10 inches diameter would drive a 200-ton machine without crushing rolls, but with crushing rolls greater power would be required; a difference in the rate of speed would also affect the operation.

Mr. Jones inquired whether it was not necessary to have an adjustment apparatus on the machine for separating the shale, seeing that the percentage of the dirt to be taken out of the coal varied so much.

Mr. Sheppard said the shale screw ran at the same speed, but there was a shale valve for regulating the exit of the shale from the washing bash.

Mr. Moxham said that no results had been given of experiments by the machine, and consequently, taking 100 tons of coal worked through the machine, they could form no idea whether it would wash out a greater or less proportion of shale than one of the old machines, assuming, of course, that the coal dealt with in both cases contained the same percentage of foreign matter before washing. It was well known that there was an enormous amount of waste in all washing machines, and the question was whether, by the improved machine, there was more coal left, and whether that coal was cleaner.

Mr. SHEPPARD said that the result of washing by his machine was that the coal and the shale were cleaner; that was, there was less shale mixed with the washed coal, and less coal found in the shale separated by the machine, and that the coke made from the washed coal was very superior.

Mr. J. T. EDMONDS had one of the old machines at work, from which, on taking up some of the washed coal, more or less shale would be found in it; and on examining the discharged shale there would be found more or less coal in it. In like manner he had examined the shale and coal from the new machine at work at Maesteg, but failed to discover a particle of coal with the shale, or any shale in the washed coal. He then examined the coke made from the washed coal, and could not find any evidence of shale in it. He did not mean to say that he examined it chemically, but it appeared to him that there was a complete separation of the coal and shale. Whether the specific gravities of the materials were unusually favourable in that case he was not prepared to say. With regard to the importance of saving the fine coal there could be no question. He might mention a case within his own knowledge where, in working an old short-stroke machine, there was an immense overflow of water from it, which became a nuisance to the neighbours. Some time after, a neighbour living lower down the stream was reported to be making some of the finest coke in the district, and on inquiry he found that the refuse water from the higher works had been turned into catch ponds made for its reception, and the fine coal deposited, from which that superior coke had been made.

Mr. BARROW said that the small coal, which was carried away by the water and lost in the old machine, was kept in agitation by the operations of the new machine, so that it was taken up and carred off by the larger particles of coal. He had introduced filter beds, and the material thus caught was so fine that if coke was to be made from that alone it would take double the time, and would not be of the same character as that made from the mixed

coal. He thought that one of the advantages of the new machine was that there was no residue.

Mr. JONES wished to have the matter put on a satisfactory basis; but to do that there ought to be a series of analytical tests of the coal previous to washing, after washing, and of the coke made from it. He thought that nothing was so deceptive as the appearance of coke. Some coke with 8 per cent. of ash might look and appear to be very good, and, at the same time, some coke with 16 per cent. of ash would look equally good. Therefore it would be most deceptive to judge from appearance, which would afford no test of the ash it contained, or of the sulphur; and the only way to arrive at a satisfactory solution was to have the coal analysed before washing and after, and also the contents of the settling ponds, and of the coke.

Mr. HENRY K. JORDAN said that there were one or two points which it might be desirable to clear up. One was to determine the best time to crush the coal; for, as Mr. Price had pointed out, if the coal was washed before it was crushed, most of the loose shale and dirt would be separated, but all the pyrites or other impurities in the uncrushed lumps of coal would not be separated, so that it was of much importance to decide the best time for crushing the coal for coke making. It would also be desirable to decide on the best form of the crushing rolls; whether one small pair of crushing rolls, or whether it would not be better to have a pair of fluted rolls over them, possibly at right angles, and with a hopper between, so that the coal should be thoroughly broken down. It was also very desirable to decide what were the best sizes into which the coal should be separated for washing. How many sizes should it be separated into? There was one point in the statements that had been made that surprised him, and that was that coal equally clean could be got where the water was used over and over again as when washed in machines which continually received a change of water. It was quite possible that coal might become clean although washed in dirty water; but it appeared to him that if the water in the

meantime was let out into a catch pond, and allowed some time to settle, instead of being used over and over again continuously, it would result in producing a purer coal, and that better results would accrue. No doubt a portion of sediment did settle in the shale tank, and that the water, being always in agitation, was always surcharged with as much solid matter as it could hold in suspension, and that the remainder went to the bottom, either in the proper dirt tank, or into the coal tank, where it got mixed with the coal again. He might be wrong, but at all events he thought it was a point to which attention should be directed. Mechanically the machine worked admirably and was a great improvement on the other machines, and he thought its further improvement would be found either in the enlargement of the tanks, or in providing settling ponds.

The CHAIRMAN said that particles of coal attached themselves to the shale, and in like manner particles of shale were attached to the coal, which were difficult to separate, even in a washing machine, and therefore it was necessary to resort to crushing. Now, with reference to crushing, it was an important point whether rolls were the proper means for crushing coal. It appeared to him that the better system would be to use the ordinary vertical roller mill, which would crush the coal as fine as necessary. No doubt some of the members would remember an experiment made at Dinas some years since, where the coal was first converted into excellent coke, and then the coke was ground fine and made into bricks of an hexagonal form. But after an expenditure of £20,000 to £30,000 had been incurred it was found to be a failure. The coke was ground fine, and then put into a very strong cast-iron mould and compressed by Condy's steam hammer into a hard substance—so hard that it bore any amount of knocking about; but when it came to be burnt under a boiler it was difficult to break up and difficult to light; but when it did light, the heat it threw out was so intense as to burn the fire-plates.

Mr. J. T. EDMONDS said that air might be employed as well

as water in the process, and he thought that air could be employed over and over again. He did not understand that they were asked to wash coal without a fresh supply of water. The only thing the new machine claimed as an advantage over the old form, was in the supply of water required being much less, which was undoubtedly of much importance where there was a scarcity of water, and it appeared that Mr. Sheppard had discovered a means by which coal could be thoroughly washed with a supply of water that would pass through a half-inch pipe; and if the smaller quantity of water effected the purpose equally well as the larger, and saved the waste of a quantity of fine coal, they ought to be obliged to the man who pointed out how such important results were to be obtained.

Mr. BARROW thought there were good reasons given why air should be used instead of water, and with that view he had instituted some experiments, but as water formed the best medium, that was, no doubt, the chief reason which had led to its general adoption. As to the question of crushing the coal, it appeared to be a waste of power to grind it, for in some parts of the coalfield the urgent question was how to utilise the fine coal that was naturally produced; and then it became a question of screening, as the nut coal, when separated from the dust, became a marketable material for general purposes, and found a market for specific purposes, for which it was quite serviceable.

The appearance of coke was certainly no guarantee as to its quality or purity. That could only be ascertained by analysis. In one case they had a coke containing 8 or 10 per cent. of ash—a fair coke in appearance, but no better in appearance than another which proved by analysis to contain 15 or 16 per cent. of ash; indeed, the worst coke by all appearance was frequently the best.

There was seldom a colliery working the same seams as another in all respects; and there were so many seams differing in various characteristics in the South Wales District, that it was seldom the same result could be obtained, even in the same

colliery, where the top, the lower, or the middle seams might be worked, or more than one, at the same time, so that the results given were sometimes very misleading. In considering those results it was necessary to bear in mind the District where the coal came from, the seam, the position, and everything in connection with it, before the truth of the analysis could be recognised.

As to the settling pond suggested as an improvement by Mr. Jordan, the settlement took place in the machine. They had, with a similar machine, an intermediate settling pond, but all the water from morning till night passed through the machine—he would not say how many times, but at least once every hour. There the settling pond was sufficient to contain an immense quantity of water, which was afterwards lifted back by a centrifugal pump, and it was from experience of that character which led to the adoption of the new machine of Mr. Sheppard, so that it was more an hypothetical case that they were arguing than anything else.

Mr. D. Thomas thought that Mr. Jordan's view, that the shale got mixed up with water and had not time to settle, was to a great extent correct. He thought if the water were allowed to pass at a slow speed, the separation of the shale from the coal would be more perfect. He had no doubt there was a great deal of shale interstratified with some coal, which, after entering the machine, went into powder or paste; and it was a question whether the coal, as it left the machine, was not to some extent coated over with a portion of that clayish shale, or whether the greater part was carried off with the harder impurities. He thought there was great difficulty in getting a perfect separation of the shale from the coal, because in some coal the shale adhered to it tenaciously, and assuming it was first crushed, particles of the shale would still be found adhering to it, even in the smallest state; therefore it was very difficult to effect a perfect separation. At the same time every encouragement should be given to a machine which produced such favourable results as that referred to in the President's Paper.

The CHAIRMAN considered that the discussion which had taken place had tended to show the importance of the subject, and he thought, in the absence of the President, that the discussion should be further adjourned to the next meeting.

The further discussion was accordingly adjourned.

ADJOURNED DISCUSSION ON THE "CWM CARN RESERVOIR."

The CHAIRMAN said that the next Paper for discussion was one by Mr. George John Jee, on the Cwm Carn Reservoir, in which he had given much valuable information well worthy of consideration.

Mr. GEORGE JOHN JEE said he should like to make a few remarks before the discussion began, more especially with regard to the rainfall, which was stated in the Paper to have been 3·74 inches. Since he had contributed the Paper he had seen a copy of "Symons' British Rainfall" for the year in which the inundation referred to occurred, and he found that Mr. Symons gave a table of the rainfall at various other stations. He might state that when he read the Paper the only data that he had with regard to the rainfall was that published in the *Hereford Times* and some other papers, stating that the rainfall as registered at Cardiff was 3·74 inches. But he found that the quantity registered at several other stations was considerably more, from the statistics that he now had, and he thought it better to now give the particulars showing the rainfall at the other stations.

Mr. HORT. HUXHAM asked whether the stations that Mr. Jee referred to were within the immediate range of his Paper, for he thought if they were outside the drainage limits of Cwm Carn they could have but little bearing on the matter.

Mr. GEORGE JOHN JEE said he had adopted the rainfall registered at Cardiff as the nearest he could then obtain to Cwm Carn, but he now found that at some other places, and especially at the Newport Waterworks, a much larger rainfall had been

registered. At Newport Waterworks, on the date of the inundation, there had been a fall of 5·33 inches during the twenty-four hours, whilst at Newport it had been 5·20 inches, at Tintern 5·31 inches, at Cardiff 4·80 inches, at Ely 4·75 inches, at the Cemetery 4·70 inches, at Caerleon 4·64 inches, and at Chepstow the gauge had overflowed after registering 4·20 inches. It might be remarked that the question of the actual rainfall did not in any way affect the general conclusions that he had arrived at, because those conclusions were based upon different data altogether. The duration of the rainfall as shown by Mr. Symons was also somewhat longer than he had stated.

Since his Paper was read he had had some correspondence with Mr. Symons as to the maximum rainfall in any twenty-four hours to be provided for in the construction of hydraulic works, which in many engineering works was stated to be something like three inches, but that mistake had arisen from want of sufficiently extensive observations; and an examination of Mr. Symons' work would at once show that that conclusion was entirely fallacious, because, as a matter of fact, at one or more stations in the United Kingdom a rainfall of at least five inches in a period of twenty-four hours every year might be expected with some degree of certainty, which, although it might not occur in any particular locality during the century, and probably would not occur during a century, still it was the fact that somewhere or other in the United Kingdom, in every year, a rainfall of the extent of five inches would be registered in the twenty-four hours. That fact would be found stated in Mr. Symons' Tables for the last ten years; and he thought it was of some importance, because, relying upon a less extensive series of observations, it might be assumed that three inches would be the maximum.

In his Paper he had also stated that the rainfall would be something less in an elevated district like that at Cwm Carn and the surrounding hills, but he had since concluded that that statement was somewhat doubtful, and he should like to reserve his

opinion upon it. Mr. Symons did not agree with it, although it was well known that the rainfall registered at great elevations was always less than that taken at lower levels.

Mr. DAVID THOMAS asked whether Mr. Jee attributed the inundation to the increased quantity of water that fell in that place. Since 1772, when the embankment had been constructed, it was probable that great improvements had taken place in the construction of works of that character; so that, if the one under discussion had been made according to the present mode of building dams, the water in all probability would not have cut its way through the bank. He thought that the disaster was to be attributed to the defective state of the embankment at the time, and not so much to the increased rainfall.

Mr. G. F. ADAMS said that Mr. Jee had done some service in putting on record a careful account of the accident, which had been brought about by the wrong construction of the reservoir, the general principles of which were pretty well understood. For want of proper management, the embankment had been allowed to get into a state of decay; the public were allowed to walk over it without any restriction, and consequently, the centre part became weakened and depressed to such an extent that it became lower than the waste weir, and thus performed the duty of a waste overflow in the very part where water ought not to have been allowed to flow over the embankment, which in the result was soon carried away. That, in connection with a leakage that had previously taken place and weakened the bank, was the direct cause of the disaster, and was not difficult to understand.

The situation was no doubt exceedingly convenient for the construction of a reservoir, but the weak point was that the stream should have been allowed to flow directly into the pond, and not conducted in by a side channel controlled by sluices. The numerous sluices passing through the embankment, as shown in the sections, led to its being much weakened, and it was also doubtful whether there was proper puddle down the centre of

the bank. He thought it was a great mistake to conduct rapid mountain streams directly into the reservoir.

The CHAIRMAN said he concurred in the remarks of Mr. Adams, and thought that that mode of conducting streams into a reservoir ought never to be allowed, as it was a source of much danger.

Mr. GEORGE JOHN JEE said that he quite agreed with Mr. Adams that the safest plan in all cases was to conduct the feeding stream into reservoirs by a side channel, but in practice that was seldom done in that district; in fact he had not noticed a single instance of it, possibly because it was more expensive; but if the storm water weirs were constructed of sufficient capacity, it was not absolutely necessary that the water should be conducted away by side channels, although it was much the safest plan to adopt in all cases.

Mr. DYNE STEEL (through the Secretary) thought that the failure of the Cwm Carn Reservoir Embankment was a matter of considerable interest, as an engineering problem, to solve, and he had taken an early opportunity after the occurrence of inquiring into it on the spot. A reservoir bank which had been in existence over seventy years would not suddenly fail without good and sufficient cause.

The Writer seemed inclined to attribute the giving way of the bank to two causes—first, weakness of construction; and, secondly, want of sufficient bye-wash and sluices.

From the former he altogether dissented. The embankment, which was so well shown on the sections, was amply strong, and would compare not unfavourably with many modern works of the kind. The slopes were of the proper angle, and the bank fairly well constructed—indeed, well constructed for its date; the chief defect being the absence of pitching on the inner slope, a want which one would have expected the owners to have supplied.

The Writer calculated that when the reservoir was full there was a pressure on the embankment of 3,367 tons, but he could only

make it 1,610 tons. The mean depth of the bank as taken from the sections (and which were ample for the purpose) was only 17 feet, not 24 feet, and the length ought not to be taken at more than 400 feet for such a calculation.

As regarded the bye-wash, it was practically little more than half the capacity of discharge given by the Writer, the width at the centre of the embankment being only 9 feet 6 inches, and through that opening, a little below the sill, all the escaping waters had to pass.

To his mind the insufficiency of the bye-wash, combined with the deplorable state of the sluices, caused the calamity. If water was suffered to run over the centre of an unprotected embankment, of the best construction in the world, it must inevitably be cut down in a very few hours; the waste of a few inches of water down a turnpike road would cut out the hardest macadam in a marvellously short time; and the water passing over the Cwm Carn embankment had cut it down, as with a knife, in the form of the breach indicated on the horizontal section, which showed most clearly how it had resulted.

The strange apathy and ignorance of the people who saw water running over the embankment, without raising an alarm, was something wonderful; and there cannot be a doubt that if such alarm had been raised no life would have been lost, and the reservoir might have been relieved in an hour or two by a gang of men cutting down and widening the bye-wash.

The embankment was amply strong, and the failure was due to insufficient and too high a waste weir, the dilapidated state of the sluices, from which they were inoperative, and the neglect of the most ordinary precautions.

The case is full of instruction, and afforded a lesson from which they might all profit, and he thought Mr. Jee deserved the best thanks of the Members for bringing forward the subject so concisely.

Mr. Hort. Huxham said that he entirely concurred in the remarks of Mr. Steel, which he thought were very much to the

purpose. It was well known to all engineers, who had the slightest experience in dealing with water, that it was one of their kindest friends when properly treated and directed, but one of their direst enemies when uncontrolled and allowed to run wild. The effect of a little water trickling over the top of an embankment was of a most subtle character, and was certain sooner or later to cut a gaping channel through the embankment from top to bottom. The speed with which that gap would be excavated would depend upon two quantities: first, the amount of water passing over it in a given time, and secondly, the height the water had to fall, or the momentum it attained; but let the stream of water be only so large as would pass through an inch pipe, it was only a question of time how soon it would cut the embankment from top to bottom, whether there was clay puddle or not.

To his mind the occurrence arose from the fact of the water having been allowed to overflow the middle of the embankment, which had either subsided somewhat in the centre, or had been trampled down or lowered from other causes, and as soon as the waste water sluices became insufficient to carry off the storm water, the level of the reservoir rose and the water overflowed at the centre of the embankment, rapidly cutting a channel, through which the pent-up water rushed out with irresistible force, sweeping everything before it, and spreading ruin and desolation in its course as described.

Near Swansea there had been some instructive lessons in making large reservoir embankments. The borough authorities had been constructing extensive waterworks, with reservoirs constructed very much in the same form as at Cwm Carn, by throwing large embankments across deep ravines, and enclosing the waters running from several mountain streams. One embankment was 70 feet high, and was designed by one of the ablest hydraulic engineers of the day. It was carried out under the direction of a resident engineer, who had under him a most ample staff of officials, and the work was supposed to be carried

out in the best and most modern way, regardless of expense. But after the work had been handed over to the town authorities, and the reservoir had been filled with water, and been in use for some few months, a small percolation of water began to make its appearance near the centre of the bank and at a considerable depth below its top. The borough engineer, to whom it was immediately reported, at once allowed the water in the reservoir to lower by means of the sluices, so as to bring it down to the level of the leak, and afterwards gradually allowed it to rise, to bring some pressure on and test the leak. A daily account of the water running through the leak was registered; and as the water was on some days more or less muddy than on others, it indicated that it was gradually carrying away portions of the bank; and in time the leak gradually increased to a little stream, which in a comparatively short time produced a crowning in, or subsidence of the bank, to its upper surface; since which time the water had not been allowed to rise above the seat of the leak, some 30 feet above the bottom.

Another large embankment (80 feet high) of a second reservoir was in course of construction, in the foundation for which much difficulty was encountered, as a bed of jointy rock was met with that had to be cut away to a depth of 80 feet below the surface before a bed of shale affording a watertight foundation was met with, and it was only at that depth that a proper foundation of cement concrete could be laid, which was ultimately carried up to the level of the surface, where the ordinary formation of the embankment was proceeded with. He referred to those works to show the highly detrimental effect that a small percolation of water might produce upon the very best-made embankment, for in that case one little imperfection in the bank allowed the water to pass through and occasion an immense amount of trouble and expense.

Mr. A. J. STEVENS said that, with regard to the evil at Cwm Carn, the first thing that struck him was the small dimensions of the overflow weir. He thought it was more than probable

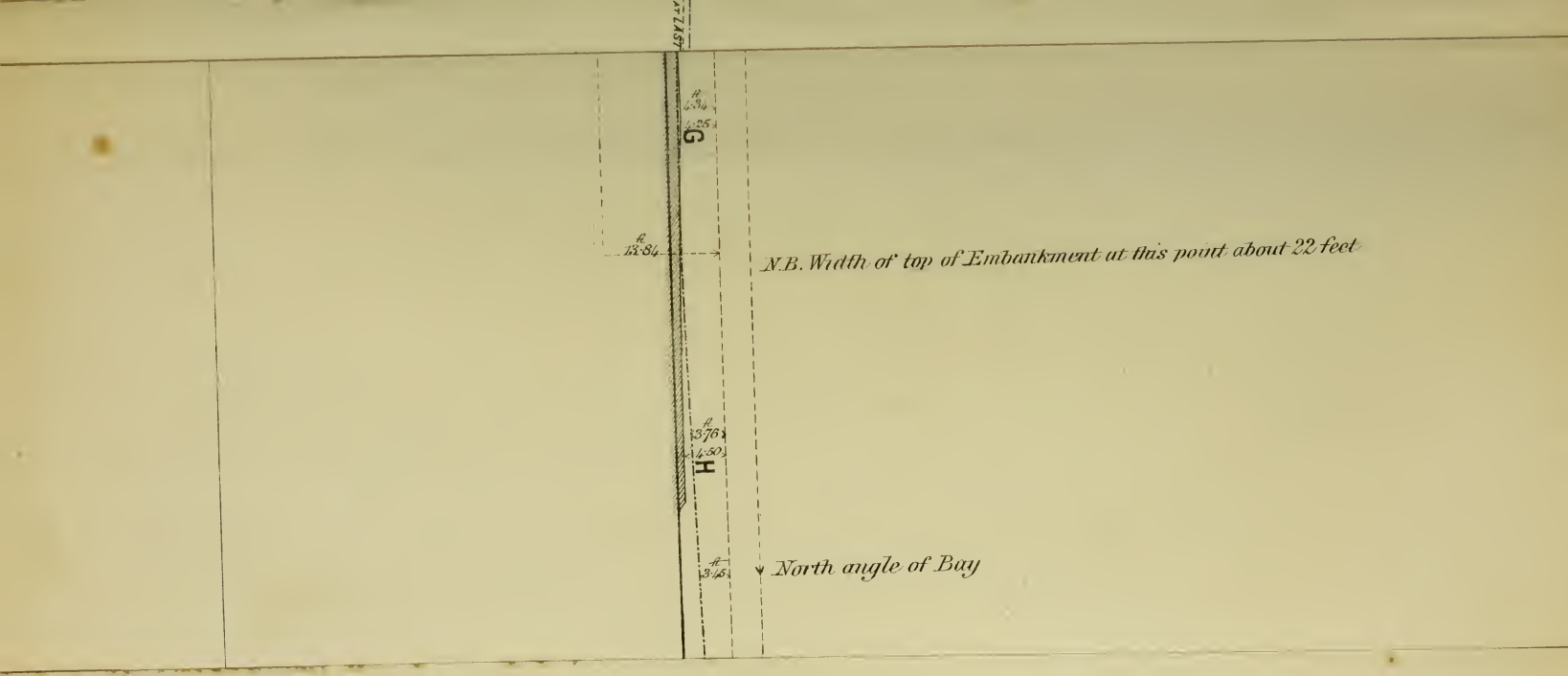
that the depression of the centre of the embankment, occasioned probably by the footpath along its top, caused the water to overflow as soon as the water-level of the reservoir was raised by the storm water, and it must have run over at one time to a depth equal to the depression in the footpath, which, to his mind, was quite sufficient to account for the almost immediate sweeping away of the embankment and its attendant results.

The CHAIRMAN said that Mr. Steel had remarked that the weir was too high for the bank. It was quite evident, then, that as the bank sunk down in the centre, it had been necessary to reduce the height of the weir, which was not a proper engineering operation. It would have been better if proper attention had been paid to the raising of the bank, and preventing any overflow, and then probably the accident would not have occurred. He now proposed that the further discussion be adjourned to the next meeting, which was accordingly agreed to.

The CHAIRMAN said that, as there were several Papers to be read, contributed by gentlemen who had especially attended from a considerable distance, he proposed, with the consent of Mr. Wilkinson, that the discussion of his Paper on "Personal Experiences in Tubbing Shafts and other Colliery Work" be postponed to the next meeting.

To this Mr. Wilkinson assented, and the discussion was adjourned.

Mr. Upward's Paper on "The Miner's Life Preserver" was then read by the Secretary.

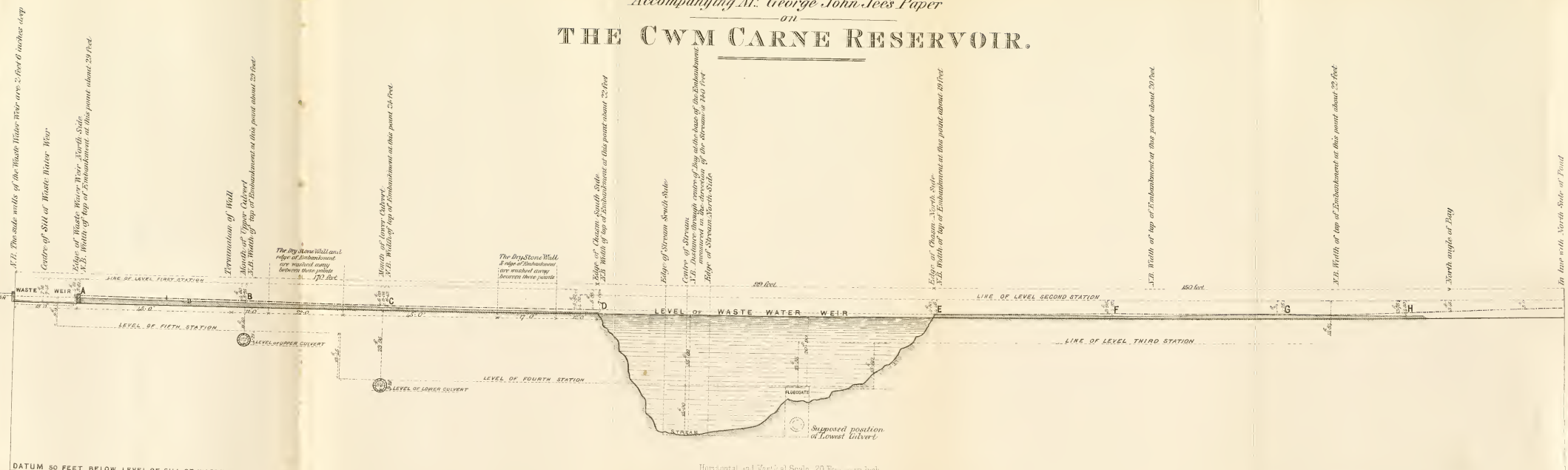

G
H
13·84
N.B. Width of top of Embankment at this point about 22 feet
13·76
4·50
3·45
North angle of Bay

LONGITUDINAL SECTION

Accompanying Mr. George John Lee's Paper

on

THE CWM CARNE RESERVOIR.


N.B. The side walls of the Waste Water Weir are 2 Feet 6 inches deep
Centre of Sill of Waste Water Weir.
Edge of Waste Water Weir North Side
N.B. Width of top of Embankment at this point about 29 Feet.
Termination of Wall
Mouth of Upper Culvert
N.B. Width of top of Embankment at this point about 29 Feet.
The Dry Stone Wall and edge of Embankment are washed away between these points
50 Feet.
Mouth of Lower Culvert.
N.B. Width of top of Embankment at this point 24 Feet
The Dry Stone Wall & edge of Embankment are washed away between these points
Edge of Steam South Side
N.B. Width of top of Embankment at this point about 22 Feet
Edge of Steam South Side
Centre of Stream.
N.B. Distance through centre of Dam at the base of the Embankment measured in the direction of the Stream is 340 Feet
Edge of Stream North Side
599 Feet.
Edge of Steam North Side
N.B. Width of top of Embankment at this point about 23 Feet.
N.B. Width of top of Embankment at this point about 20 Feet.
150 feet.
N.B. Width of top of Embankment at this point about 22 Feet.
North angle of Dam
In line with North Side of Pond
LAST STATION
WASTE
WEIR
A
B
C
D
E
F
G
H
LINE OF LEVEL FIRST STATION
LINE OF LEVEL SECOND STATION
LINE OF LEVEL THIRD STATION
LEVEL OF WASTE WATER WEIR
LEVEL OF FIFTH STATION
LEVEL OF UPPER CULVERT
LEVEL OF FOURTH STATION
LEVEL OF LOWER CULVERT
PLUGGATE
STREAM
Supposed position of Lowest Culvert
DATUM 50 FEET BELOW LEVEL OF SILL OF WASTE WEIR

Horizontal and Vertical Scale 20 Feet to an Inch

(Proceedings S.W. Inst. Engrs 1877 N.S. Vol. II).

N.B. The edge of the Embankment next the Pond is numbered 1 and is drawn thus ——1——

The outer edge of Do is numbered 2. Do

The Level of the Water when the Reservoir was full Do

The letters A. B. &c. refer to Cross Sections

A. Reid, Newcastle on Tyne.

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CROSS SECTIONS

Accompanying Mr. George John Jees's Paper

on

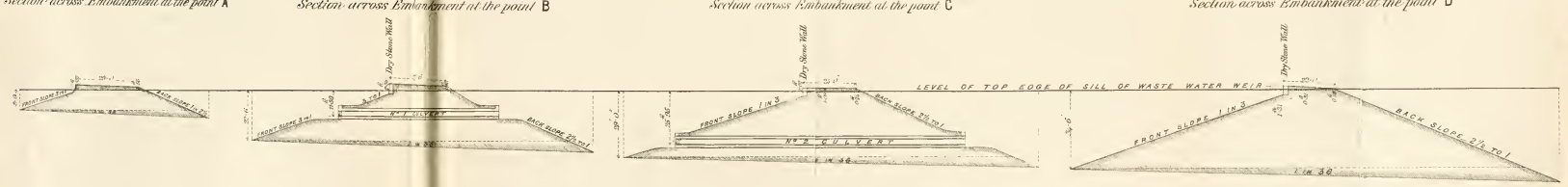
THE CWM CARNE RESERVOIR.

Section across Embankment at the point A

Section across Embankment at the point B

Section across Embankment at the point C

Section across Embankment at the point D


Dry Stone Wall
LEVEL OF TOP EDGE OF SILL OF WASTE WATER WEIR
FRONT SLOPE 3 to 1
BACK SLOPE 2½ to 1
N.º 1 CULVERT
N.º 2 CULVERT
1 in 30

Vertical and Horizontal Scales 40 Feet to an Inch

(Proceedings S.W. Inst. Engrs 18.º 71 N.º 3. Vol. I.

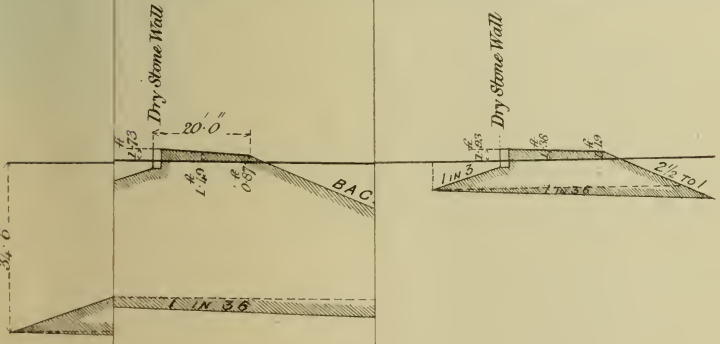
SECTIO

George John

on

RNE R

Embankment at *tion across Embankment at the point* H



al Scales 40 Fe

(Proceed

A Reid Newcastle on Tyne

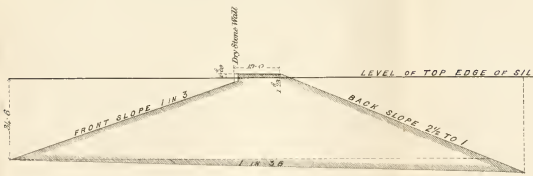
CROSS SECTIONS

Accompanying Mr. George John Lee's Paper

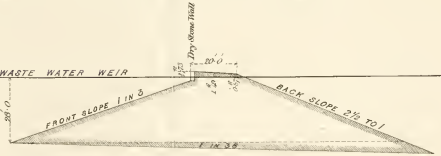
on

THE CWM CARNE RESERVOIR.

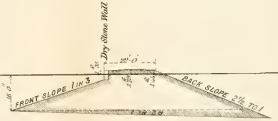
Section across Embankment at the point E



Section across Embankment at the point F



Section across Embankment at the point G



Section across Embankment at the point H

Vertical and Horizontal Scales 40 Feet to an Inch.

(Proceedings S.W. Inst. Engrs. 1877) N°3, Vol. 10

ON

"THE MINER'S LIFE PRESERVER."

By Mr. A. Upward.

(Communicated by the Secretary.)

This apparatus was designed by the Writer, consequent on the accident which happened in April last at Pontypridd, when five miners were entombed for ten days without food; a catastrophe which naturally drew considerable attention to the methods to be adopted for rescue under such circumstances.

Had such an apparatus been at hand in time, it must both have considerably shortened the duration of the unfortunate men's imprisonment, and also allowed food and other necessaries to have been conveyed to them pending their release.

The Writer would first briefly narrate the circumstances of the accident, and then proceed to the description of the apparatus which he took with him to the scene of the disaster, but which was not actually used, as the men were rescued just before its arrival.

The catastrophe was caused by a rush of water from a flooded working adjoining the mine where the accident occurred. The men endeavoured to escape, but were driven back into one of the stalls, where they remained until rescued. The water rose rapidly behind them, and drove back the air, highly compressed, into their stall. During the first days of their imprisonment they burnt candles, but when these were exhausted they were in total darkness.

It was discovered that it might be possible to reach the

imprisoned men by driving through a pillar of coal from an accessible point in an upper level, and for a while all went on apparently well, the miners achieving wonderfully rapid progress in cutting a passage through the coal, though, as may be well imagined, it was, at best, a fearful race against time. As, however, the imprisoned men were approached, several unexpected dangers presented themselves; gas made its appearance in the workings, and greatly impeded the progress of the rescuers. But a fatal accident revealed a very serious and unexpected danger. On breaking through the coal where the condensed air was confined, it escaped with such force as to cause the loss of the life of one of the men, hurling him with violence into the orifice. It was not surprising that under such circumstances even brave men hung back, saying "it was death to go on." They, however, continued their work of rescue, notwithstanding the dangers they knew they had to face. Holes were made through the wall of coal, in hopes of being able to pass in a supply of food, but that was rendered abortive by the escape of the air, which kept it back, and moreover the imprisoned miners, finding the water rising in upon them, immediately did their best to stop the holes with coal-dust, besides which they could only be communicated with when the holes were plugged, as the noise made by the escape of the air was deafening. At length, however, in desperation and at extreme risk both to rescuers and the imprisoned miners, the wall was broken through, and the miners, now almost up to their necks in water, were dragged out of their prison.

It will be seen, then, that if the escape of the compressed air could have been prevented, the principal danger of the rescue would have been overcome, and food, light, and other necessaries might have been passed to the imprisoned miners, without any danger of the water rising on them, and thus their sufferings would have been greatly mitigated.

The apparatus which the Writer took with him to the scene of the accident was a modified form of that which he had

already used for some years past with perfect success, for the purpose of drilling and tapping gas, and water mains, and steam boilers *under pressure*, and inserting taps therein.

He had, therefore, no doubt of being able to cope successfully with the compressed atmosphere in which the miners were enclosed, as he had had considerable experience of pressure far higher than any that was likely to be encountered at the scene of accident.

He could not, indeed, consider it otherwise than a most unfortunate circumstance that he did not happen to have his attention earlier called to the features of the accident; for had the instrument been used which he took with him, the life of one man would certainly have been saved, and the miners fed during their imprisonment.

The description of the apparatus was as follows:—Fig. 1, Plate 18, represented the apparatus for passing food, communications visible in the dark, or other necessaries for the preservation of life. A was a piece of timber fixed in the floor and roof of the mine, and was used for fixing the struts KK, furnished with right and left-handed screws, with which the apparatus was firmly held to the face of the coal, the escape of air or gas being effectually prevented by india-rubber or other packing P, which was placed between the flange of the apparatus and the face of the coal. C was a movable chamber above the slide-valve, in which was placed the vessel F for passing food, lamps, and other necessaries to the imprisoned miners. G was a pressure-gauge for ascertaining the pressure of the compressed air. V was a slide-valve which could be opened and closed at pleasure, and gave the operator full command over the compressed air, gas, or water that might be confined in the mine. R was a rod passing through a stuffing-box B, and to which the boring apparatus was fixed, and by which the vessel F was pushed forward to the imprisoned miners, after opening the slide-valve V; that valve was closed whenever it was necessary to open the chamber C, either for the introduction of drills to make the hole through the

coal, or for the passage of the vessel F, containing food &c. for the miners. Z was a covered port which could be opened or closed at pleasure, affixed to the bottom of the slide-chamber, for the purpose of clearing it, should coal dust or other obstruction enter that chamber, and so hinder the due action of the slide.

It was proposed also to add the following subsidiary apparatus, guarded by stop-cocks and furnished with screws, one of which was to be affixed to the hose of the air-pumps, and by means of which a continuous stream of air could be forced in, and the pressure in the confined space maintained to any required extent; and to the other stop-cock a pipe was to be connected, for the purpose of withdrawing the vitiated air.

A glass lens, with a strong light behind it, may be fixed to the chamber C, to reflect a beam of light through the hole bored in the coal. That might be employed in cases in which an explosive atmosphere was suspected, and would enable the imprisoned men, even under such circumstances, to read written communications, and pass back replies with perfect safety.

It would be evident, then, from the description, that the apparatus gave the means of furnishing men in the situation of the imprisoned miners with the three great requisites of life, viz. food, air, and light, and thus prolonging indefinitely the time during which rescue could be attempted. Besides which, it would be seen that in the case of the Pontypridd miners the pressure of the enclosed air would have been entirely under control, and that any accidental leakage through fissures could have been adequately supplied. Thus in their case the water could have been kept back, and under perfect control, and without any danger from a sudden release of the confined air, which might so easily have proved fatal to both the miners and their deliverers.

Fig. 2 represented an apparatus of larger dimensions than Fig. 1, but in other respects altogether similar. In that case the chamber C was sufficiently large to admit the vessel D to hold a man.

The miner took his place in D, was drawn back into the chamber C, the valve closed, and the pressure relieved by opening the cock. He was then withdrawn from the chamber C, and was released. The value of such an apparatus in the late accident, had it been at hand, would be evident, and though probably the occasions on which it would be required would not be very frequent, still two accidents, one in Belgium, and another in America, with features much resembling those of the Welsh accident alluded to, showed that it would probably be so often required in a large mining district as to make it worth while to be kept in readiness at some accessible spot.

Fig. 3 represented a smaller apparatus, furnished with telescopic screw S, for pressing the boring apparatus forward, but in other respects similar to Fig. 1. It was intended for ascertaining the state of the mine when approaching old flooded workings, or accumulations of gas, &c. It had the great advantage, that the bore hole was always entirely under control, and the gas or water could by means of it be drawn off at pleasure. It also allowed the hole to be effectually plugged, without danger, and under any pressure of water or confined air.

It was indeed not easy to foresee how often this apparatus might prove most efficient in preservation of life and of mining property.

It was hardly to be expected that each mine owner should possess a complete set of apparatus, especially of the large one described in Fig. 2. Probably all that would be reasonable in that respect would be that the apparatus shown at Fig. 3 should be found as part of the stock of all well regulated mines. He would suggest, however, that depôts should be formed in different mining districts, at which apparatus of the kind should be deposited, from whence they could be rapidly forwarded in case of emergency, to the spot where required. Those depôts should be furnished not only with the above-described apparatus, but with portable engines, air and water pumps, constructed so as to travel by road or railway; medical and surgical appliances, adapted specially

to mining casualties; and, indeed, such stores as the experience of the district suggested as being most useful in cases of mining accidents. Those depôts should be, of course, in the most accessible part of the district. They ought, he thought, to be sufficiently supported by voluntary effort on the part of mine owners and miners. They should be officered by tried hands, and their staff should be from miners chosen for practical experience, coolness, and courage. Efficiency should be maintained by periodical inspections, presenting rewards and decorations to the efficient. Means should also be taken to make miners generally acquainted with their duties, in assisting what might be termed the "miners' brigade." The brigade would speedily attain a valuable practical insight into the best method of proceeding in cases of accident. In a word, they would be exactly analogous to the "lifeboat crew" or "fire brigade" of a great city, and would no doubt speedily display the same kind of cool practical courage, the same readiness in resource, and the same steadiness in discipline, as those crews and brigades had always shown.

The CHAIRMAN said that the apparatus had been brought for their inspection by the inventor, who would, no doubt, be happy to make clear any part requiring further explanation. It might be asked whether the machine had been invented since the Tynwydd accident, or was it partly an invention of previous origin.

Mr. UPWARD said the apparatus had been invented since the accident; but the smaller apparatus which he had placed on the table was the one he took with him to the scene of the accident, and which they would see was somewhat similar to that which he had since produced. There were many little points that he had designed to meet some of the difficulties which he had found to exist; but the principle was similar to the apparatus which he had made many years ago for tapping gas and water pipes in London, where it was the usual practice to cut the hole by hand, but he need hardly say that not a single hole could be

made round. Therefore he designed an apparatus by means of which it was practicable to tap a gas or water pipe under pressure, or even a steam boiler, and insert a cock without the loss of one atom of pressure. The small apparatus before them was that which was intended for that purpose, and was suitable for tapping, under heavy pressure, either gas, water, or steam. In using the apparatus, it was placed upon the water main, and a joint made by means of an india-rubber washer, the whole apparatus being held down firmly on the water pipe. The boring instrument was then put into the circular chamber of the apparatus, and attached to the rod which passed out through the stuffing box attached to the valve case. The sluice valve was then opened, and the boring bit allowed to fall upon the pipe, and worked round by means of a ratchet brace until the hole was bored through the pipe, when the borer was again brought up into the hollow part just above the slide valve, and the slide valve closed. The hole had then been bored and the pipe tapped, and the next thing was to put in the tap without losing the water. To effect that the boring bit was taken off, and the tap attached in the chamber to the rod passing through the stuffing box, and the valve chamber closed, when the slide valve was again opened, the tap carried forward by the rod and screwed into the hole; when the apparatus was taken off, leaving the tap screwed into the water main.

He had slightly modified that system, and made it applicable to the exigencies of the mine in the manner exhibited before them, and shown in Figs. 1, 2, and 3, Plate 18; and he should be happy to answer any questions upon the matter.

Mr. G. F. Adams said that he thought the plan shown in Fig. 2 was better adapted for such accidents, because, rather than waste time in trying to feed the imprisoned men, it was, he thought, better to get them out of danger, and that was what the apparatus would enable them to do. He did not quite understand how the chamber was made airtight, but assumed that it was under control by means of the sluice valve. He apprehended that, as a man could be got out by the apparatus, so, in case of need, a man could be passed in.

Mr. UPWARD said that the process only had to be reversed: the man was placed in the vessel D, which was screwed on to the rod R in the chamber C. The outer valves were then closed and the slide valve opened, and the man passed forward to communicate with the imprisoned miners. It was a point that had not occurred to him before; but he saw the force of it, for a man could thus speak to miners who might not be able to write, and who might be in a state of panic.

Mr. A. J. STEVENS inquired what weight the apparatus was estimated to be.

Mr. UPWARD thought it might be made about 3 cwt. It was very light, and the only part really requiring strength was the disc, which required to be heavy enough to withstand a pressure of 20 lbs. to the square inch. The weight of the chamber might be about 2 cwt., making altogether some 5 cwt., but it would be in separate pieces.

Mr. W. THOMAS asked what would be the necessary diameter of a tube to take a man.

Mr. UPWARD had taken 18 inches, but it might be 20 inches.

Mr. THOMAS said that, if he assumed that a person was put inside the cage D and chamber C, he desired to know from what source he derived fresh air whilst shut up in the tube and being passed in through the hole.

Mr. UPWARD said that the air would first follow him until the valve was closed, after which taps might be opened communicating with the external air until a communication was gradually established between the chamber in which he had been placed and the compressed air in the mine. That would have to be done gradually, and that was the reason why those small taps were used, so that the valve could be regulated even to the 100th of an inch.

Mr. THOMAS thought that the machine was exceedingly ingenious, but that it was better adapted to the surface than to underground use, because there were so many difficulties to contend with, especially at great distances from the shaft, that

SECTIONS OF APPARATUS AS FIXED FOR USE,

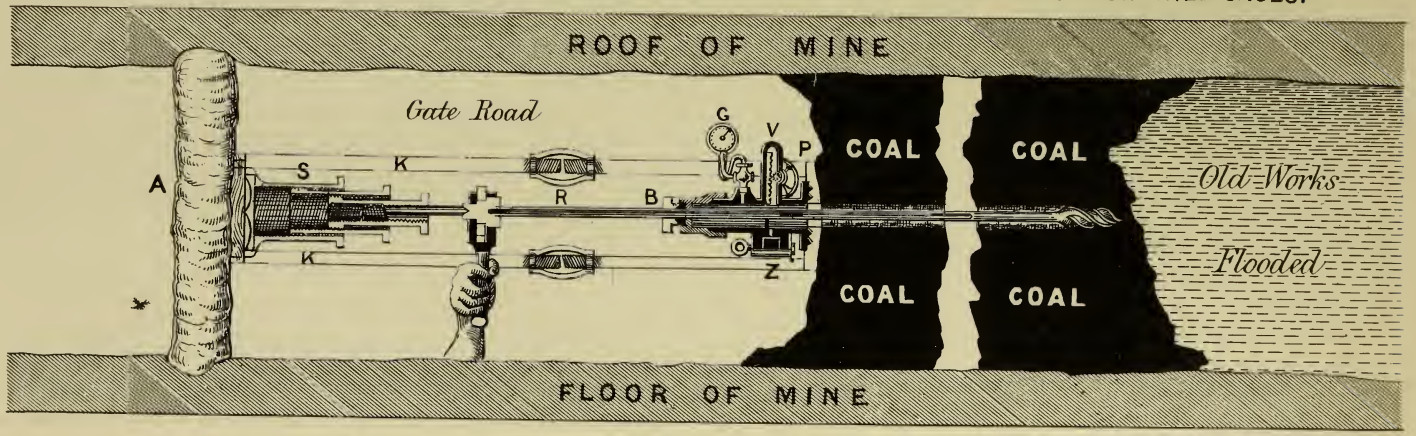
Illustrating Mr. A. Upward's Paper

on

THE MINERS LIFE PRESERVER.

FIG. 3.

APPARATUS FOR ASCERTAINING THE STATE OF MINE AS REGARDS APPROACHING DANGER SUCH AS THE PRESENCE OF OLD FLOODED WORKINGS OR THE PRESENCE OF CONFINED GASES.



(Proceedings S.W. Inst. Engs: 1877) No 5, Vol. 10

SECTIONS OF APPARATUS AS FIXED FOR USE,

Illustrating Mr A. Upward's Paper

on

THE MINERS LIFE PRESERVER.

FIG. 1.

APPARATUS FOR PASSING FOOD, MESSAGES & OTHER NECESSARIES TO IMPRISONED MINERS.

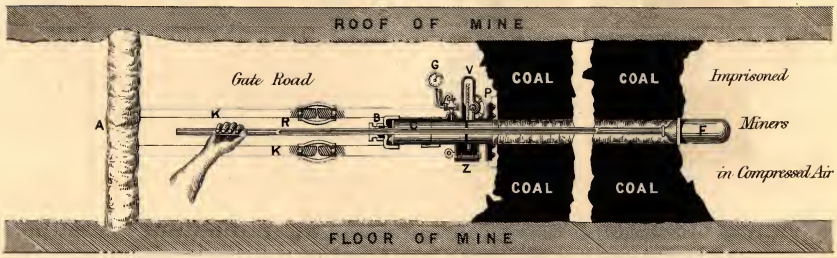
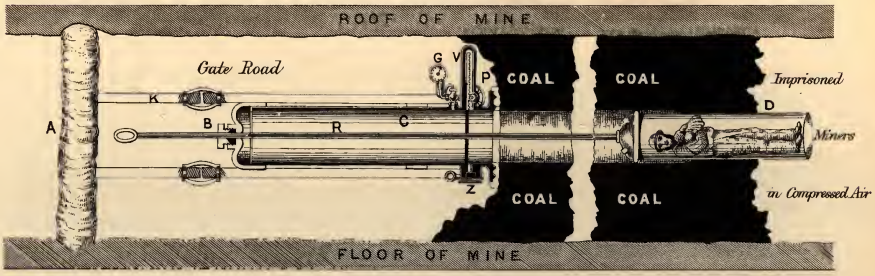


FIG. 2.

APPARATUS FOR DELIVERING MINERS FROM THEIR ENTOMBMENT.



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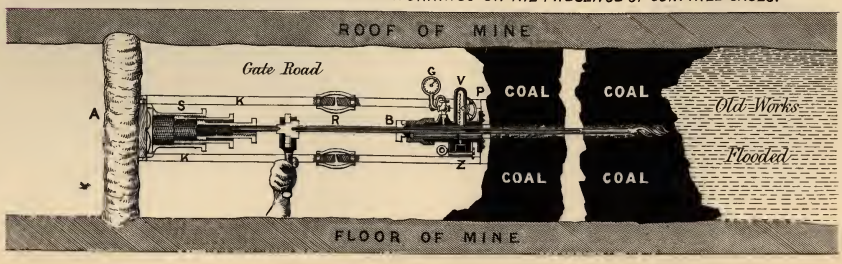

(Proceedings S.W. Inst. Engs. 1877) N°5, Vol. 10.

A. Reid, Newcastle, on Tyne

they would not be able to reckon on using it in the same manner as could be done on the surface.

Mr. UPWARD said he was determined to make the apparatus perfect, and he was glad to hear the observations that had been made, and was desirous that it should be criticised thoroughly, because it was only by those means that the defects would be remedied. He had not brought the subject before them with the expectation of no objections being found to it, but, on the contrary, he felt that any practical objections that were raised would only be an incentive to him to remove them in a practical manner.

Mr. D. THOMAS said that, from what he could see, it would require a massive machine to make a bore-hole of sufficient size to be of practical use, and if it were to be worked by mechanical means it might probably save time and expense. There also appeared to be some difficulty as to securing an airtight joint between the flange of the apparatus and the coal.

Mr. UPWARD said that since he had been in the room several suggestions had been made, which showed him that when the coal was jointy and full of fissures the small flange would have to be replaced by a large one, which could be arranged by having a large board, and a joint round that, with the machine fixed outside.

Mr. T. F. ADAMS said that men could only be removed out of compressed air by means of some apparatus combining the principle that was ordinarily used in sinking piers for bridges, and which could be seen in operation at the Severn Bridge works; and it appeared to him that they must rather fall back upon an apparatus of that kind, or airtight doors.

Mr. UPWARD said that his apparatus did away with doors, and enabled the men to be removed, under any pressure, with great ease. Means were taken to keep up a proper pressure by pumping air in; but, in cases of danger and peril, no means should be lost even in saving one life; and if he heard that one life was saved by means of his apparatus, he should be amply rewarded for his trouble in designing it.

Mr. Henry K. Jordan said he had known the Writer for many years, and knew the ingenious apparatus with which he had contrived to drill holes in pipes where water existed under great pressure. The apparatus now before them was also a most ingenious mechanical contrivance; but it occurred to him that the net in which the man was placed would drop down unless special means were taken to prevent it. Assuming the person was put into the cage and it fell down in passing through, how could the man extricate himself? Then another point was as to the means of signalling to the man inside, for the man should be able to communicate his wishes, whether to be withdrawn or left there. Probably that might be effected by a bell, or some other contrivance of that nature.

Mr. Thomas thought the apparatus was an ingenious piece of mechanism. He feared, however, that great difficulty would be met with in dealing with a bore-hole of 18 or 20 yards in length, and of the large size that had been indicated, because so much must depend upon the quality of the coal to be bored through, and a question would arise whether the hole might not collapse in soft coal. There were some seams in which he had no doubt a bore could be successfully conducted, and that the coal would stand without breaking, but it would be questionable whether the hole could be preserved without protection or tubing in all cases.

Mr. Upward said it was comparatively easy to line the bore-hole, but, being of a circular form, it was naturally strong; but he thought that in the case of saving life no cost or objection ought to have weight in the application of all possible means.

The Chairman said that they had to thank Mr. Upward for coming there that day, and they hoped to have the pleasure of seeing him at the next meeting, to which the matter discussed would be adjourned, and he thought that the suggestions which had been made would probably enable him to bring it forward in a more perfect form.

The CHAIRMAN said there were three other Papers for reading: the first, on "Safety Lamps," by Mr. W. E. Teale; the second, on an "Improved Fire Bar," by Mr. M. Moxham; and the third, by Mr. Galloway, on "Sinking and Boring Operations under Water Level by means of Compressed Air"; and he suggested that, as those gentlemen were present, their Papers should be taken as read and ordered to be printed, and that each gentleman should shortly explain the objects of his Paper.

Mr. W. E. TEALE said he had fully explained the principle and details of his lamp in the Paper and by the diagrams in Plate 19, and he would ask the permission of the meeting to have the discussion adjourned to the next meeting but one; and meantime, perhaps, many gentlemen would conduct experiments with the lamp, and have observations to make, based upon the results. The lamp would thus become better known, and they would be able to pass a more decided opinion upon it. He could add a great deal; but in the Paper he had given them the reasons upon which he claimed the superiority of the lamp over others as a mechanical construction. The results obtained were safety as to the non-explosion, increased brilliancy, and economy in the consumption of oil.

Mr. WILKINSON did not think there was any difficulty about the lamp, which appeared clear to him. He should be glad to know where the lamps were used, and if there were any danger from the oil.

Mr. W. E. TEALE said that the main features of the lamp were these:—It was fitted to burn a particular oil, called colzaline. Nothing could run out after the oil-chambers were charged, because the sponge absorbed all the oil; the means of locking were such that it was impossible to withdraw the light; and to put the light out it was requisite to unscrew the lamp top from the bottom, in doing which the light was put out by withholding the air which supplied it. The superiority of the light could be noticed even in the daytime; but, when tested by the photometer, it amounted to 25 per cent. more than

the best of other lamps, and the economy was very great. With regard to the oil, there was no danger, beyond the fact that there was a certain amount of risk with all oils if not carefully used. The lamp would burn for fourteen hours at a time before requiring to be replenished. In some collieries there were from 500 to 1000 lamps in use, and they had never experienced the slightest difficulty with them, and the lamps were in use in some of the most fiery collieries in the district of South Yorkshire.

The lamp was a little more expensive than the ordinary one, and possibly double the price of some lamps sold; but the cost of the lamp was so very small compared with the saving effected, that it was repaid after a short time by the saving in the oil. The actual price was £7. 10*s.* per dozen, or 12*s.* 6*d.* each.

Mr. WILKINSON did not think that was worth consideration if the lamp were effective, and great economy would arise in the difference in the price of the oil that was used, being 2*s.* per gallon instead of 3*s.* 4*d.*

The CHAIRMAN inquired whether the lamp had been used in an explosive atmosphere, and had an opportunity of being tested with gas. Was the light put out when brought in contact with gas, or did the lamp continue to burn and the gauze get red hot?

Mr. TEALE said the light was more sensitive than with ordinary lamps to the action of gas, and it was more easily extinguished than the oil lamps, and the gas would put it out. He had tested it with several others, and found that the Stephenson went out in a current of 15 feet per second, whereas the Protector would withstand a velocity of 20 feet per second without any explosion taking place.

One of the most efficient lamps was that in use in the Belgian pits, and hence called the Belgian lamp, of which there were over 60,000 in use in that country. The principle he had drawn attention to was applicable to the Stephenson, as well as to the Clanny and Davy lamps.

Mr. HORT. HUXHAM inquired whether there was any mode of getting the sponge out of the lamp bottom.

Mr. W. E. TEALE said that could only be done by taking the lamp bottom to pieces. If the oil were good the sponge would last as long as the lamp.

The discussion was then adjourned to the next meeting.

The CHAIRMAN then invited Mr. Galloway to explain the apparatus which he had exhibited in illustration of his Paper.

Mr. GALLOWAY said that the principle of the apparatus was an invention which was made in 1837 by the late Thomas Cochrane, Lord Dundonald. All that he had done was to show how that principle could have been applied to the Tynewydd accident. The apparatus consisted of a chamber into which the men passed before they came out from the compressed air, and from which, after the compressed air had been allowed to escape, they passed out by a door. The plan and section, Plate 22, represented the drift in the Tynewydd Colliery where the workings were flooded. The vertical heights between the levels were shown by the sections. The water rushed into the colliery and compressed the air in the stall shown on the plan. Afterwards the water was pumped out of the middle level, to which access was then obtained, when, by the sound of knocking, it was discovered that the men were imprisoned in the stall, although up to that time it had been thought there was no life left in the colliery. The plan first adopted for rescuing the men was to pump the water down to the point from whence a drift could be driven towards the imprisoned men, and then prepare a small air chamber provided with an outer and an inner door, and a cock to control the pressure. The chamber was intended to be made in the drift, to be driven down, and to be filled with air at a pressure equal to that which was inside, where the men were imprisoned, and then to cut a communication through to the men. That was attempted, but the water rose; and, though sound in principle, it might be asked why it had not been successful.

The model before them represented the whole thing: and

showed the levels, the drift driven down from the upper level to within three or four yards of the place where the men were imprisoned, and also the stall in which the men were imprisoned below the level of the drift.

Between the two spaces there was a barrier of three yards of coal. At the top of the drift, near the middle of the level shown on the plan, were placed the air doors, or air chamber. When compressed air was pumped into the space or chamber until the pressure was equal to the pressure in the stall, it was possible for men to pass through the inside door to cut away a communication into the imprisoned men. Suppose the outer door opened, and a man went in and shut the door behind him, he would then have to open a cock which communicated with the air chamber; and, after the chamber had been filled with compressed air, he would be able to open the second door and communicate with the place containing compressed air. In the converse, the men would come up into that chamber and close the inside door, after which the pressure should be let off, and the other outer door opened and the men come out. It was found that 45 lbs. pressure to the square inch was the limit that men could bear without being injured. When he was at the Severn Bridge recently, they were working with compressed air at 25 lbs. for erecting the piers, and they expected to be up to 40 lbs. with some of the deepest piers before they finished the bridge.

The discussion was then adjourned to the next meeting.

A vote of thanks to the Chairman closed the proceedings.

ON

"SAFETY LAMPS."

By Mr. W. E. Teale, of Manchester.

(Communicated by the Secretary.)

The prevention of explosions in collieries was one of the most important questions connected with coal mining. The loss of life and property, so frequently attending an ignition of gas in an explosive state, was greater than from any other distinct kind of accidents incidental to the work. Fires not unfrequently occurred, which, though not so destructive to life, still often caused immense loss and expense to the owners. The main cause of those accidents almost entirely arose either from the use of powder and naked lights, or from defective safety lamps. The chief object of the writer of this Paper would be to point out what was essential to render safety lamps worthy of the name.

It would doubtless be admitted that without the invention of Sir Humphrey Davy, George Stephenson, and Dr. Clanny, coal mining would have been carried on to a much smaller extent than it was at the present time.

Prior to the introduction of the Davy the phosphorus of a fish skin was often the means used for giving the light necessary to work by; and, later on, the sparks given out by a steel wheel revolving against a flint were used for the same purpose.

It is needless to refer to the large number of modifications that have from time to time been brought before the mining world as improvements upon the three lamps before mentioned,

but in the result their use has in nearly every instance been abandoned from some cause or other.

Sir Humphrey Davy encircled an oil flame with a cylinder of wire gauze, and so long as the lamp was fed by pure air, the flame burned with the ordinary brightness of an oil flame, but if passed into an atmosphere of fire-damp mixed with air the flame enlarged and gradually became less luminous until the light left the wick, and the gas which filled the interior of the gauze continued burning with a spiral motion, giving only a light-blue flame; and although the gauze might be surrounded by the inflammable mixture of gas, the flame does not ignite it.

The explanation given by Professor Tyndall, in his work on "Heat as a Mode of Motion," was as follows. He says:—"With regard to a flame, its molecular motion is very intense, but its weight is extremely small, and if communicated to a heavy body the intensity of the motion must fall." If a piece of wire gauze, which will readily admit of air or gas passing through its meshes, be placed over a lighted gas jet, not a flicker of the flame passed through; and if the gas be allowed to stream through the gauze without being first lighted, it can readily be lighted above the gauze without igniting the gas beneath, although the space was filled with gas in a condition eminently favourable to ignition, which Tyndall thus explains: "A certain heat is necessary to cause the gas to ignite, but by placing the wire gauze over the flame, or the flame over the wire gauze, you transfer the motion of that light and quivering thing to the comparatively heavy gauze. The intensity of the molecular motion is greatly lowered by being communicated to so great a mass of matter—so much lowered, indeed, that it is incompetent to propagate the combustion to the other side of the gauze."

Thus in the Davy lamp there was a covering for the flame which rendered the lamp practically safe under ordinary circumstances, provided that every man underground was sufficiently educated to know that when the flame enlarged he was in a dangerous atmosphere and would take advantage of the warning;

that each man could be relied upon not to tamper with his lamp; and if there were no sudden outbursts of gas; under which circumstances the Davy lamp might safely be relied upon. In the hands of practical and intelligent men, it was still considered the safest lamp, but not for the ordinary collier's use.

The Clanny and Stephenson were modifications of the Davy, the former giving an increased light and additional safety in some respects; the latter a decreased light, but still further increased safety under extraordinary circumstances. In considering what constituted the chief and essential features of a safety lamp, it might be stated that the most important points were—1st, that the covering should be of such a character that no ignition of the surrounding gas could take place; 2nd, that the lamp should, for a given size, be able to produce the greatest amount of light; and, 3rd, that when once placed in its covering, no possibility of exposing a naked light should be practicable.

The construction of the lamp should be strong and simple. As regarded the covering, wire gauze 28 by 28, or 780 square meshes to the square inch, was considered the standard and most suitable for the purpose. Many instances of its failing under pressure of explosive gas would no doubt be known to many of the Members, and that knowledge led the North of England Institute of Engineers to carry out a series of tests, proving that 8 feet per second was sufficient to pass the flame and ignite the gas surrounding a Davy lamp; 9 to 10 feet per second through a Clanny; and 11 to 12 feet per second for a Stephenson.

Since then the Belgian Government, owing to repeated accidents arising from the use of naked lights and faulty lamps, instituted a Commission for the purpose of investigating the question of safety lamps. That investigation was carried on from 1867 to 1876, when the conclusion was arrived at that the Museler type of lamp would withstand the greatest velocity of explosive gas passing over it without causing an explosion, and its use was now rendered compulsory by law.

The immense number of experiments conducted by the

Commission with all kinds of lamps, under every imaginable condition, rendered their decision of much value.

In the Museler lamp it must be apparent to all that it would be difficult to pass a current direct through the top. The construction of the chimney, and the increased diameter of the gauze, was eminently calculated to absorb and reduce the temperature of the flames, the conical form of the chimney also contributing to the safety, its diameter being sufficient to carry off the ordinary results of combustion; but when the lamp had, in addition, to consume the gas passing into it, the chimney checked and threw down the carbonic acid gas upon the flame, causing its certain extinction, and in that way it was conducive to good ventilation, and also compelled the collier to take more care of his lamp. In England also the same class of covering was becoming better known, and largely adopted in some districts.

From a collier's point of view the poor light given by safety lamps was the main cause of objection to their use, and any improvements in that direction would do more to remove his objection than anything else. It was rarely a week went by but an explosion took place from the use of naked lights in collieries, showing how much the collier risked to obtain a good light, and that some better lamp was required; the great complaint had been that there was no *safety lamp*; for lamps fitted up with different kinds of locks had been tampered with, for various reasons, and no doubt in some cases out of sheer recklessness.

Practically, however, there never would be a perfect safety lamp unless an illuminating body could be produced that would give the necessary light without a flame, or a possibility of igniting gas. That such was not beyond the bounds of possibility was evidenced in the use of fish skin, throwing its phosphorescent light; but pending some new discovery in that direction there was no reason why any improvement that contributed to the increased value of the safety lamp and thereby rendered mining safer, should not be carefully investigated, and, if found to attain its object, be adopted; and it was believed that

at the present time the highest degree of safety and efficiency had been reached by the Protector lamp, examples of which were on the table before the Members.

The principle was by no means new, having been some five years before the public, and during that time, like most innovations, it had met with much criticism from a great number of gentlemen connected with collieries, and its success was due in a great measure to the objections, raised to it from time to time, having been met, so that during the last three years it had come largely into use.

The lamps exhibited were the Protector, Clanny, Stephenson, and Museler; and also a Fireman's and Dialling lamp. They were all arranged to burn colzaline oil, with asbestos wick.

The Clanny, Stephenson, and Museler lamps were fitted with the Protector lock.

On referring to Plate 19, which represented the Clanny lamp, Fig. 1 showed the case and upper part of the lamp; Fig. 2, a Vertical Section of the complete lamp; Fig. 3, the oil reservoir and screw; Fig. 4, the extinguishing or regulating tube; and Fig. 5, the Protector bolt. The glass cylinder B was firmly held in position by the plate C, which had in its centre a hole D, threaded inside to receive the screw K of the regulating tube (Fig. 4). Within that tube was cut a deep square thread to correspond with the burner L in Fig. 3. The slide marked I in the same figure covered the oil feed hole. The reservoir O was filled with sponge, from which proceeded a permanent wick N, extending to within $\frac{1}{3}$rd of an inch from the top, which was completed by the addition of an asbestos termination M. In the operation of trimming the lamp, the reservoir was filled with colzaline and turned upside down quickly. The extinguisher (Fig. 4) was then placed on the burner, and screwed into the aperture D, in the plate C. The bolt C, with the half circle end, and which fitted into the snug F, was then pushed home and locked the extinguisher, the spring upon the bolt became released and pressed against the casing of the lamp E, and could not be again removed

until the reservoir was detached from its covering, in doing which the extinguisher, being fast, remained behind, whilst the flame was extinguished by the action of unscrewing the lamp bottom, on account of its being cut off from its support of material for combustion. It will be readily seen how simply and securely the lamp was locked, and how impossible it was to expose the naked light when once the two parts were fixed.

It had, however, been pointed out, that although the light could not be exposed, the collier had the power of taking off the lamp bottom, and by means of a match, relighting the lamp without detection; and no doubt that was correct.

To meet that objection, three different arrangements had been made, viz. the screw, lock, and the lead pin in two forms. The first, in conjunction with the Protector, formed a good lock; for a collier was not likely to tamper with it when he knew that he could not remove the top without extinguishing the light; and the lead pin passing through the bolt acted as a detector, and prevented the lamp after it had been relighted from being put in its place again without detection.

In the second form, the lead pin with the square plug prevented the lamp from being opened without first cutting off the plug.

The colzaline used in the lamp was especially made for it, and produced the purest and brightest light of any known oil. It was always of one uniform quality, and required less oxygen to support combustion; and, unlike the heavy hydro-carbons, gave off no smoke. If placed in a given quantity of atmospheric air it would burn a longer time than a similar sized flame produced from the ordinary oils so generally used. In consequence also of the greater purity of flame, and its higher temperature, the presence of a smaller percentage of carburetted hydrogen was more readily detected and seen more distinctly.

Another advantage was that the combustion of the colzaline produced no perceptible odour, and there was no consumption of the wick. The oil was conveyed up the wick tube purely by

capillary attraction, and the wick only required the removal of a small portion of its top when it had caked.

When the oil was in the reservoir it was held suspended in the sponge, and could not run out; and, as it was antagonistic to grease or dirt, the gauze was always kept clean. The oil was inflammable, but not explosive or dangerous, and it would not ignite unless at a temperature equal to flame heat, and might be boiled in a crucible without ignition. It was not affected by concussion or friction, nor would it ignite spontaneously.

The question of economy was one that required some notice, although the highest degree of safety, with the view of saving life, should be the first object sought. Owing to the variety of oils used, and the difference in price, it was difficult to give a comparative test. But it might be stated that, as compared with colza oil, there was an economy of fully 50 per cent. in favour of the colzaline, independently of the saving of cost in the wick. A gallon of colzaline would burn in a still atmosphere in a Clanny lamp without the top, and give a good light for upwards of 1,000 hours. If moved about, and the flame kept at one even height, it would burn for 780 hours, the difference in time being accounted for by the wafting of the flame. As used in collieries, and where the flame was generally allowed to remain sufficiently high to burn clearly, 650 hours was the time it would take to consume a gallon of oil, of the value of two shillings, in one lamp.

Again, 200 lamps, each lamp to burn on an average 48 hours, would consume 16 gallons, equal 32*s.*, and would cost $1\frac{7}{8}d.$ per 48 hours per lamp. Taking the cost of new lamps, an outlay of £180 would provide 100 lamps and oil sufficient to supply them upwards of three years.

Justice would not be done to the question without pointing out that, unless the system in connection with the use of safety lamps be carefully considered, and a good one adopted, the advantage to be derived from the use of the most effective lamp could not be gained. The Writer had long been of opinion that everything in connection with safety lamps ought to be kept

strictly out of the hands of the men. The lamps should be kept on the colliery premises, cleaned, trimmed, inspected, and locked, before being placed in the hands of the men, and, when done with, should be returned to the custody of the lamp-man, for, amongst other reasons, when the lamps were taken home by the men, they were often improperly cleaned and trimmed, and there was not time for the proper inspection of the lamps at the pit on the men returning to work, and it was too serious a matter that the neglect of one man should jeopardise the lives of many. The lamp-room should be fitted with appliances to prevent waste and to ensure proper cleaning and trimming. The work was too often left to incompetent men (frequently from motives of philanthropy) long past work, whereas the post should be filled by a really good active man, and in the end the saving effected in the wear and tear of the lamps and waste of oil would be considerable.

The following Regulations were abstracted from the conditions rendered compulsory in respect to safety lamps by the Belgian Government in June 1876:—

"Art. 3.—The safety lamp must be shut, locked, and remain deposited in the lamp-cabin; special agents are to see that the lamps are made clean, and maintained in good order by experienced workmen.

"Art. 4.—At the time of descending, the lamp is given to each workman, who must assure himself that it is locked.

"Art. 5.—The lamp which happens to go out in the mine must be sent to the surface or to a place in the mine, where they shall be examined, reopened, lighted, and locked, by a man exclusively appointed for that purpose, acting under the supervision and direction of managers and deputies. The places or stations where lamps ought to be relighted shall be fixed by the order of the chief engineer, and notified in the registry of standing orders.

"Art. 6.—It is strictly prohibited to open lamps elsewhere."

The Writer was of opinion that if night cleaning and trim-

ming were done away with, the lamps would receive more careful attention, and there would be less risk of an imperfect lamp escaping detection, and although the plan might entail an increased first cost, it would eventually pay for *itself*.

The following analysis of the light from a Protector and Geordie oil lamp was made by Mr. Thomas Harrison, of Manchester, in 1871:—

Spectrum of Protector Lamp, burning Colzaline Oil.

Rays.	Without Gauze.	With Gauze.
Red (Heat Rays)	100	90
Orange (Partial Light and Heat)	100	85
Yellow (Light)	100	80
Green	100	70
Blue	100	60
Indigo, Actinic	100	30
Violet	100	None
	700	415

Thus 70 per cent. of the light passed the gauze, and 15 per cent. of the actinic rays.

Spectrum of the Geordie Lamp, burning the Finest Colza Oil.

Rays.	Without Gauze.	With Gauze.
Red (Heat)	100	45
Orange (Subdued Light)	100	70
Yellow (Light)	100	60
Green	100	45
Blue (Partly Light)	100	35
Indigo, Actinic	100	25
Violet	100	25
	700	305

Relative Power of Both Lamps.

	Protector and Colzaline Oil, with Gauze.	Geordie and Colza Oil, with Gauze.
Red	100	45
Orange	100	85
Yellow	100	100
Green	100	50
Blue	100	45
Indigo	None	25
Violet	100 = 600	None = 350

Remarks.—The oil lamp gave off 30 per cent. less light, and less than one-half the actinic rays.

In addition to the foregoing observations, he found that the

oil lamp gave a double line in the yellow ray, proving the presence of sodium, and to some extent an imperfect combustion, whilst the Protector gave an unbroken continuous spectrum throughout.

In testing with explosive gas H_2O he found the new lamp very sensitive, and much more so than the oil lamp; the new lamp was immediately extinguished; the oil lamp made two or three spirts previously.

The following comparative tests were made by Mr. J. Longden, of Blackwell Colliery, in May 1877 :—

Description of Lamp.	Photometer. No. of Lamp.	Height of Flame.	Diameter of Wick.
Clanny Protector, Naked Light .	$\frac{7}{8}$	$1\frac{1}{2}$	$\frac{9}{32}$
„ „ with Top on .	$1\frac{1}{4}$	$1\frac{1}{2}$	„
Jack „ Naked Light .	$1\frac{1}{4}$	1	„
„ „ with Top on .	$4\frac{2}{4}$	1	„
Museler „ Naked Light .	$1\frac{1}{3}$	$\frac{7}{8}$	„
„ „ with Top on .	$1\frac{1}{2}$	$\frac{7}{8}$	„
Protector, Dialling, with Top on .	2	1	$\frac{7}{32}$

Tested in a current of air, by placing in a box 1 ft. diameter :—

Protector, Clanny	3,200	Not out.
„ Jack	2,600	Went out.
„ Museler	3,200	Not out.
Oil, Clanny	2,800	Went out.

Remarks.—The asbestos wick enabled the lamp to remain lighted in a greater current of air.

The Museler burnt brightest at 3,200.

All Protector lamps filled with colzaline, and asbestos wick.

Flame, the maximum, without smoke in all cases.

The asbestos powder was put into a lamp gauze, and then placed in one of the boiler flues and allowed to remain until the gauze was white hot. On turning the asbestos out and allowing it to cool, it was found in almost the same condition as when put in, thereby showing its indestructibility by fire.

In order to show the nonliability of the oil to grease the gauze, the small cap of a Davy lamp was placed over a flame in such a manner that the point of the flame played against the top of the gauze. With a glass the colzaline was allowed to drop on the hot gauze, and consumed away inside without leaving any

THE PATENT PROTECTOR SAFETY LAMP.

Illustrating Mr. W.E. Teale's Paper

on

SAFETY LAMPS.

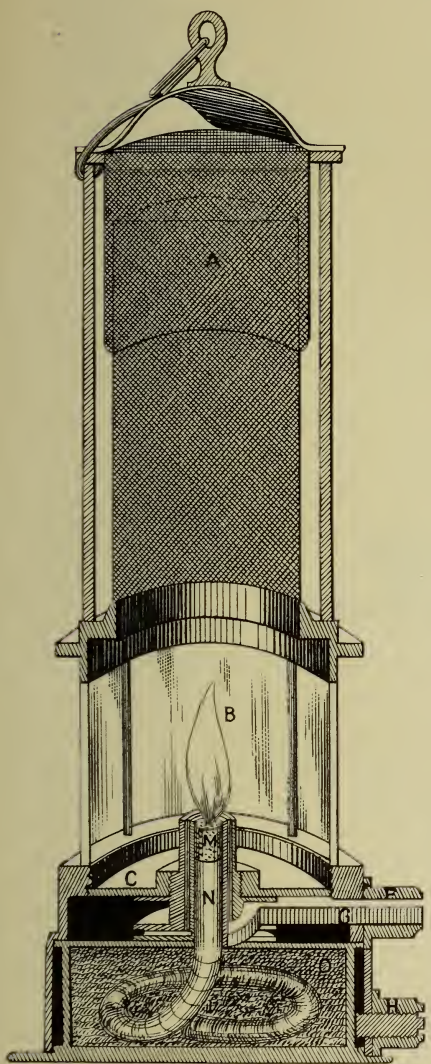

FIG. 2.

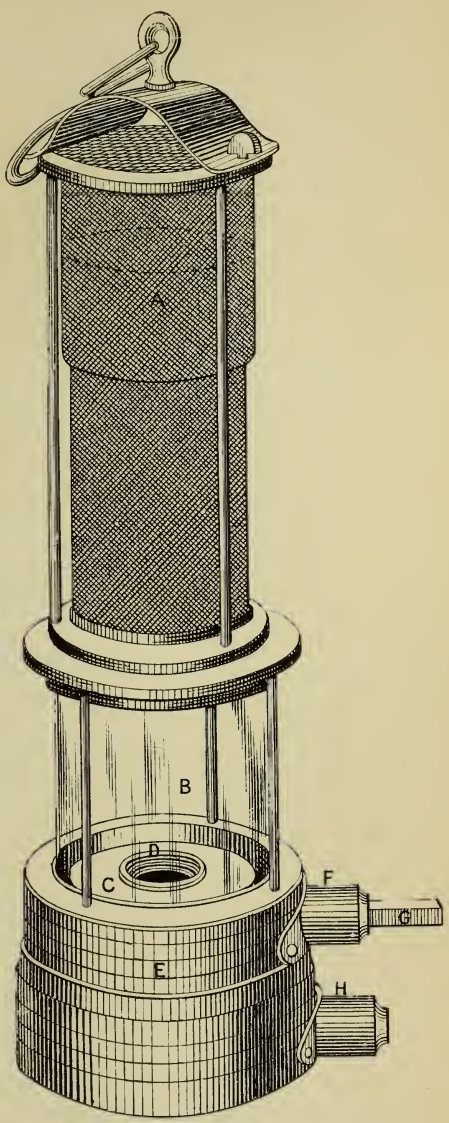

FIG. 1.

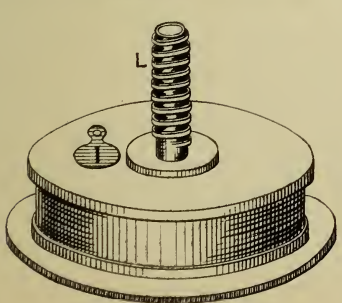

FIG. 3.

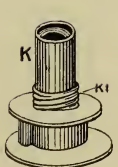

FIG. 4.

FIG. 5.

(Proceedings S.W. Inst. Engs. 1877) N°5, Vol. 10.

A. Reid, Newcastle on Tyne.

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smoke, soot, or grease. The oil was placed on a planed board, and after ignition burned away without charring it. To test the nonexplosive nature of the oil when heated, some of it was put into a retort and allowed to boil over one of the lamps. The result proved that a temperature sufficient to boil it would not cause it to ignite, so long as the vapour was kept away from a naked light. Some of the oil was put into a copper dish, and a bar of iron heated black red was placed within a quarter of an inch of it, and subsequently put into the oil, but in neither case did it fire. The bar was then heated to a dull red, and passed rapidly over the oil without touching, but it caused no ignition. It was put into the oil, which ignited and continued to burn until it was all consumed.

A large number of the Protector lamps were in use and doing good service. The question of a more secure method of lighting collieries was deserving of close investigation, and was a matter that must interest many of the Members, as it was certain to be the means of reducing the loss of life and property arising from the use of imperfect and so-called safety lamps.

ON

AN IMPROVED HOLLOW FIRE-BAR.

By Mr. Marcus Moxham.

The object of the invention noticed in the following short Paper was to produce a Fire-Bar constructed in such a manner that it should under all circumstances remain cool, and not burn away so as to require frequent renewal, like the ordinary Bar, whilst, at the same time, freely admitting the air through the fire, and producing almost perfect combustion with some coals.

The improved Fire-Bar was in outward form much the same as that ordinarily used, but it was cast *hollow*, and had one end closed up. Along each side near the upper surface of the Bar, a number of small perforations, or air holes, were cast, equal in area to that of the hollow inside of the Bar, and forming a communication with the hollow centre as shown in the section, Fig. 1, Plate 20. The bearing Bar across the front end of the furnace was also cast hollow so as to form an air chamber, and at proper intervals hollow lugs were cast on it to receive, and form a joint with, the end of each Fire-Bar, so that one end of each Fire-Bar was thus connected with the air chamber; the other end of the Bar being supported in the usual way.

In connection with the furnace, fitted with bars of that construction, was placed a blower or a fan, worked by any mechanical arrangement at the works, so that a continual supply of air should be driven into the air chamber, and through the bars into the fire; or a Körtings patent steam jet blower might be advantageously used for that purpose. It was also found better not to have any opening under the Fire-Bars to admit

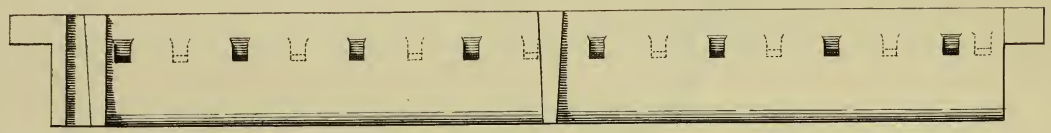
PLAN OF PERKIN'S PATENT FIRE-BAR,

Illustrating M.r Moxham's Paper

on

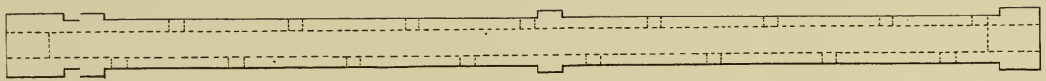
AN IMPROVED HOLLOW FIRE-BAR.

FIG. 1.



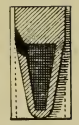
ELEVATION.

FIG. 2.



PLAN.

FIG. 3.



CROSS SECTION.

(Proceedings S.W.Inst:Engs:1877) N°5 Vol.10.

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the air in the usual manner, but to keep the fire-place perfectly closed up.

In most large towns the authorities have endeavoured, as far as possible, to compel those using steam power to consume their smoke. Many means have been tried, but probably the simplest would be by using the hollow Fire-Bar above described.

The Writer had two ordinary Cornish boilers in use, fitted with the hollow Fire-Bars, one worked by a fan, and the other by a Körtings steam jet blower. The length of the ordinary Fire-Bars that were originally used was 6 feet 6 inches, and the length of the new hollow air bars was 5 feet. Originally about 9 inches in thickness of fire was maintained, when using bituminous or steam coal, but now it was found that about 6 inches of steam or anthracite coal would produce the same effect. The saving of fuel was found to be quite 15 per cent., and when using steam or anthracite coal there was no smoke whatever. The hollow Fire-Bar was also found to work very well with a small portion of bituminous coal, and some of it was also used to damp up the fires at night.

If the hollow Fire-Bar were applied to steamers with a Körtings steam jet blower, there would probably be a large saving in the amount of fuel consumed.

The hollow Fire-Bar was found to keep cool, and not burn away to any appreciable extent, and the combustion was so improved that nearly every particle of fuel was consumed, effecting an important saving in what previously fell through the bars unconsumed. It was also found that no clinker adhered to the bars, and that the fires were much more readily cleaned and attended to.

The Bar which the Writer exhibited, and which showed little or no signs of wear, had been in use for above twelve months, in the ordinary working of a boiler attached to a stationary engine in Swansea, and the condition of the Bar was direct evidence of the value of the invention in maintaining its efficiency over a lengthened period, and of the saving to be effected thereby.

ON

EXCAVATING BELOW WATER-LEVEL WITH THE AID OF COMPRESSED AIR.

By W. Galloway.

In view of the events which transpired at Tynewidd Colliery in April last, in connection with which the apparatus about to be described had almost played a prominent part, the Writer ventures to hope that the following short account may prove not uninteresting to the Members of the Institute.

It was invented and patented by Sir Thomas Cochrane (commonly called Lord Cochrane), in 1830, and was described in the following terms at page 2 of his specification (No. 6,018) :—

"My invention consists in an apparatus for compressing atmospheric air within the interior capacity of subterranean excavations, sinkings, or mines, or within those portions of that capacity where the operations of excavating, sinking, and mining are going on, in order that the additional elasticity given to the included air by aid of my apparatus may counteract the tendency of superincumbent water to flow by gravitation into such excavations which are filled with compressed air, and maintained full of compressed air by aid of my said apparatus, and which apparatus, at the same time that it is adapted to retain the said included air in a state of compression in order to prevent or diminish the influx of water or semi-fluid earth, is also adapted to allow workmen to carry on their ordinary operations of sinking, excavating, or mining, by working underground within the

space which is filled with compressed air, and also to allow workmen a ready passage to and from the said space into the open air, or to and from the said space into those parts of the said excavations or mines which contain air in a natural or ordinary state of elasticity."

From the foregoing description, as well as from the perusal of the remainder of his specification, it was apparent that the distinguished inventor contemplated the application of his apparatus to two distinct kinds of work, namely: sinking vertical shafts, and driving horizontal drifts; it was also further obvious that the invention itself was directly inspired by a careful contemplation of the unprecedented difficulties which were presenting themselves at that very time in the work of constructing the Thames Tunnel. That great engineering triumph was, however, successfully carried out by means of Brunel's shield; and, as far as the Writer had been able to ascertain, Lord Cochrane's apparatus did not appear to have been practically applied until 1839.

At that date M. Friger, a French engineer, who was probably an independent inventor, sank a shaft to a depth of 65 feet through alluvium, in an island of the Loire, by means of an apparatus which was identical in principle, but slightly different in detail; and since then that method of contending with watery and running ground had been extensively resorted to, both in Europe and America, for the purpose of sinking mining shafts and piers for bridges, lighthouses, &c., in many situations where those operations could not, probably, have been carried out at all by any other known means.

The apparatus employed for sinking shafts (*see* Plate 21, Fig. 1) consisted of an air-tight cylindrical lining, usually composed of cast-iron rings or segments, with their flanges projecting inwards; sometimes, however, it was made of sheet iron, or even of timber, but in every case it had a smooth exterior. At the bottom the cylinder had a cutting shoe, to enable it to penetrate the ground

more easily; at the top it had an air-tight cover, and an ante-chamber, or air-chamber. In some cases the cover was made in the form of a cap to the cylinder, and then the ante-chamber was attached to one side of it, as in Fig. 1, Plate 21; in others the ante-chamber was placed on the top, and then its base constituted the cover. In the first arrangement the cap and ante-chamber were solidly joined to the cylinder, with which they descended as the work of excavating proceeded at the bottom. For that reason the cylinder was made of such a length, or height, to begin with, that, when its cutting shoe reached its destination, its top should have only descended to the level of the surface, and the cap and air-chamber should not require to have been detached from it during the operation.

In the second arrangement the ante-chamber was a fixture at the level of the surface, the cylinder being lengthened at the top in proportion as it descended, and an air-tight joint was formed between them by means of a packing ring.

The ante-chamber was the only means of entrance and exit to and from the interior of the shaft; it had two doors, one communicating with the outer air, the other with the shaft, and two or more stopcocks, by means of which it could be placed in communication either with the shaft or the outside, as might be desired, without opening the doors.

A pressure of air, corresponding to the column of water represented by the depth of the cutting shoe below the natural level of water in the surrounding ground, was constantly maintained in the interior of the column. The bottom of the shaft was thus kept dry even in the most watery or running ground, without the aid of pumps or any other appliances for raising water; and the workmen could excavate uninterruptedly, and without inconvenience, as easily as they could do so in the same kind of ground at the surface. The stuff was drawn up to the top of the shaft in buckets, which were either passed through the ante-chamber to the outside, or emptied into an inclined

tube furnished with doors at its two extremities, and ejected from it by closing the inner door and opening the outer one.

One door of the ante-chamber must, of course, always be kept shut when the other was open. Supposing that it was necessary for a workman to enter the shaft, and that the outer door of the ante-chamber was open, he would step into the ante-chamber and shut the outer door, then open the cock which communicated with the shaft, so as to allow the compressed air to flow into the ante-chamber, and when the pressure on each side of the inner door had become assimilated he would open it and pass into the shaft. In order to leave the shaft, on the other hand, the inner door being supposed open and the outer one shut, he would step into the ante-chamber, close the door behind him, open the cock communicating with the outside, and thereby allow the compressed air in the ante-chamber to escape, and when the pressure had decreased to an equality with that of the atmosphere outside, he would open the outer door and step out.

The loss of compressed air consequent on opening and shutting the doors of the ante-chamber was made up immediately by the air compressor, and thus fresh air was being constantly supplied to the workmen inside, whilst the vitiated air escaped through the air-chamber, through the ground at the bottom, and in other ways.

That method of sinking shafts or piles was limited to a depth of 90 or 100 feet below the natural level of the water in the ground, as it was found that greater pressure than $2\frac{3}{4}$ or 3 atmospheres were apt to have an injurious effect on the workmen.

The pressure of air in the shaft was regulated by observing a manometer and controlling the speed of the air-compressor according to its indications; a safety valve was also generally provided, and its load varied to suit the pressure required at any given stage of the operations.

On the 1st of January of the present year, the Writer visited the works of the railway bridge that was being constructed over the Severn, near Lydney. The superstructure rested on hollow cast-iron piers of great height, the bases of which reposed on the solid rock underlying the sand and mud at the bottom of the river. Each pier was six feet in diameter, and made up of a large number of rings with the flanges projecting inwards, by means of which they are bolted together. The total depth of the water and sand, or mud, which varied from 30 to 70 feet, and more, having been ascertained at the point where a pier had to be sunk, the cylinder was made of corresponding length by being bolted together on the spot, and let down as far as it would sink in virtue of its own and additional weight with which it was loaded. An air-tight cap, with a small air-chamber on one side, was next fitted to the top, which projected to a considerable height above the river at that stage of the operation; an air-compressing engine, with a vertical boiler and proper air tubes, was provided, and then the apparatus was ready for work. The inner door of the air-chamber having been closed, compressed air was forced into the cylinder or pier, and the water gradually expelled from its interior, escaping through the ground at the bottom. When the water had disappeared, workmen passed into the cylinder through the air-chamber, and excavated the ground under the cutting shoe as necessary. As the column sank gradually, it was kept in a vertical position by excavating more or less from one side, or the other, as might be required.

The stuff was drawn up in buckets by means of the engine, which, for that purpose, had a horizontal shaft passing through a stuffing box in the side of the cap, and provided with a pulley on which the bucket rope, or chain, coiled; it was then emptied into an inclined tube, such as had been already described, and in that way ejected to the outside.

When the solid ground was reached, the sinking was carried on in it to a depth of about four feet or so, to ensure a proper

foundation, and then concrete was filled into the vacant space to establish a permanent junction between the base of the pier and the rock bottom.

The Writer examined minutely the air-chamber, air-compressor, and the other arrangements for sinking one of the piers, in company with Mr. Recchenbach, the resident engineer of the works, to whom he was greatly indebted for the courtesy with which he facilitated his investigations.

It would extend the limits of his Paper too far to give other illustrations of this method of contending with water, or enter into more details than he had already done; but he would refer those who wished to become better acquainted with it to Sir Thomas Cochrane's specification; to Ponson's "Supplément au Traité de l'Exploitation des Mines de Houille," Vol. I., pp. 228, et seq.; and to Cullen's "Lectures on Mining," translated from the French by Dr. Le Neve Foster and himself, Vol. I., pp. 304, et seq.

He commenced his Paper with an allusion to the recent inundation at Tynewidd Colliery, and he now proposed to discuss the connection of his subject with that incident.

The proposal to employ an air-chamber in that case, for the purpose of releasing the five colliers from a stall under the level of the water, was part of the plan of operations sketched out by himself soon after they were discovered to be alive; and although official duty prevented him from superintending that part of the operations, he understood that an attempt was made to apply it. That attempt was a failure, but from what cause he had been unable to ascertain; and since it was, he believed, the first instance in which the use of an air-chamber of that character had failed as a mode of ingress and egress to and from a space containing compressed air, he thought that a description of the apparatus actually employed, as well as its mode of application and the cause of its failure, would be of much value, not only to the Members of the Institute, but to the cause of

science, and he hoped that such information would be supplied by some one present at the operation.

The situation in the neighbourhood of the stall in question immediately after the inundation might be described as follows: The seam of coal, which was about 3 feet thick (*see* Plan and Section, Figs. 2 and 3, Plate 22), was inclined at an angle of about 9 degrees to the horizontal, and was traversed by three parallel levels, known as the upper, middle, and lower; the first and second being 35 yards apart, and the second and third having 81 yards of coal between them. The upper level was accessible after the inundation, and formed the base of most of the operations; the two lower ones were, on the other hand, filled with water, which stood at a distance of only 15 yards from the upper one, measured along the inclined bed of the coal. All three were connected together by an engine incline at another part of the workings. All the coal between the upper and middle levels had been taken out, with the exception of a barrier 10 yards in width along the dip side of the former, and a few triangular pillars on the rise side of the latter; and the space thus formed was vacant. Five yards in width had also been taken off the edge of the solid coal on the dip side of the roadway of middle level, and the space stowed up with rubbish.

The coal between the middle and lower levels was, for the most part, unworked; but at that point there was a stall driven in it from the lower level, directly towards the rise, to a distance of 42 yards. At the upper end, or face, the stall was 15 yards wide, and at the lower end it contracted towards the entrance, where it was only 7 yards wide.

The water which flooded the colliery rose, as already mentioned, to within 5 yards of the barrier on the dip side of the upper level, and consequently it entirely submerged the block of coal containing the stall just referred to; in doing so, however, the air in the stall became compressed, and held back the water to a distance, it is said, of 35 yards from the face, and the

five colliers who managed to escape into it were thus preserved from drowning, although they were actually under the level of the surrounding water. It was the knowledge that this stall *must necessarily* contain compressed air *and be habitable* that led to the discovery that the men had taken refuge there.

Of the four plans that might have been adopted for releasing them, the two following appeared to present the best chances of speedy success. These were:

1. To pump the water as rapidly as possible, and, as soon as the middle level was dry, to cut towards the stall from a point directly to the rise of it, keeping pace with the descending water level in the rest of the workings; then to pause at a distance of a few yards from the face of the stall until the water level was reduced somewhat below that point; tap off the compressed air with a borehole, thereby *allowing the water to rise nearly to the face*; and, finally, to cut through the remaining distance and take out the men.

2. To pump the water as before, and cut the coal with the utmost possible rapidity, presumably faster than the water could be lowered in the workings; then to pause at a distance of a few yards from the face of the stall, fit in an air-chamber at the upper end of the newly cut drift, pump air into the space below it until the pressure was *equal to or greater than* that in the stall, put a borehole through the remaining barrier, and allow the pressure on each side of it to become assimilated *without allowing the water in the stall to change its original level;* and, lastly, to cut a narrow passage through the remaining barrier, stowing the coal in the space above, and take out the men through the air-chamber in the usual way.

A collateral operation which was not calculated either to help or hinder the others was also attempted, but did not succeed. That was an endeavour to succour the men with air and food by means of divers, and thereby render their ultimate release a certainty, even if it could not be effected for a lengthened period.

The sequel appeared to show that, if pumps of rather more than double the power of those that were actually used had been employed, the men could have been released by the first of the two foregoing methods as quickly as by the second. It so happened, however, that the coal was cut at more than twice the rate at which the water level fell; the unsuccessful attempt was then made to apply the air-chamber; and, afterwards, there followed two days of delay, at the end of which the men were got out.

He would pass over without comment the events that were reported to have occurred during these two days, and would only call attention to what must also have been abundantly evident to everyone present, that if the whole of the compressed air had been allowed to escape, either by a borehole or otherwise, before the water level had fallen below the face of the stall, the colliers inside would have been inevitably drowned.

PROCEEDINGS.

25th October 1877.

The Ordinary General Meeting of the Institute was held at the King's Head Hotel, Newport, on Thursday the 25th of October 1877.

Mr. JAMES BROGDEN, F.G.S., President, in the chair.

The Minutes of the last General Meeting were read and confirmed.

ELECTION OF NEW MEMBERS.

The President announced that the Ballot Lists had been opened, and declared the following gentlemen to have been duly elected as Members of the Institute, viz.:—

As Member.

Mr. W. Galloway, H.M. Inspector of Mines, Cardiff.

As Graduate.

Mr. Edmund James Jones, Student Mining Engineering, Dowlais.

ADMISSION OF NEW MEMBERS.

The following gentlemen, elected at previous meetings, were then formally admitted to the Institute by the PRESIDENT, and signed the Roll Book, viz. :—

Mr. Robert D. Burnie, Swansea.
„ William Walters, Briton Ferry.
„ Richard Cowper, Tredegar.
„ Charles Sheppard, Bridgend.
„ Thomas Evans, Bridgend.

RETIRING OFFICE-BEARERS—SESSION 1876–77.

The PRESIDENT declared the list of Office-Bearers retiring by rotation for the Session 1876-77 to be as follows, viz. :—

President.

Mr. James Brogden, F.G.S.

Vice-Presidents.

Mr. David Thomas.
„ Richard Laybourne, M. Inst. C.E.

Members of Council.

Mr. James M'Murtrie, F.G.S.
„ J. R. Waddle.
„ George Birbeck.
„ Marcus Moxham.
„ G. F. Adams, F.G.S.
„ Matthew Bates.

Secretary.

Mr. Hort. Huxham, F.G.S., M. Inst. C.E.

NOMINATION OF OFFICE-BEARERS—SESSION 1877–78.

President.

Mr. Richard Laybourne, M. Inst. C.E.

Vice-Presidents.

Mr. David Thomas.
„ Jas. M'Murtrie, F.G.S.

Members of Council.

Mr. J. R. Waddle.
„ George Birbeck.
„ Marcus Moxham.
„ G. F. Adams, F.G.S.
„ Matthew Bates.
„ E. P. Martin.

Secretary.

Mr. Hort. Huxham, F.G.S., M. Inst. C.E.

The Discussion of Papers read at previous meetings was then proceeded with.

ADJOURNED DISCUSSION ON "THE PENCOED, MYNYDD-Y-GAER, AND GILFACH-GOCH MINERAL DISTRICTS."

The PRESIDENT said that the first subject for discussion was Mr. Henry K. Jordan's Paper on "The Pencoed, Mynydd-y-gaer, and Gilfach-Goch Mineral Districts."

Mr. HENRY K. JORDAN said that he wished to refer to a remark made by the President, which would be found at page 168 of No. 4, vol. 10, where it was stated that "he could not see any ground for supposing the 'Rock Vawr' to be the 'No. 3 Rhondda." It appeared to him that it was beyond human power

to establish their identity, because the Moelgilau Fault was greater than Mr. Birbeck supposed, and appeared to have destroyed the whole chance of recognition between the seams on the north and south of it."

Now it appeared to him (Mr. Jordan) that if a stratum, or group of strata, on each side of the fault could not be correlated, then the magnitude of the fault could not be measured, and in that case he failed to see how the President could arrive at the opinion that Mr. Birbeck had under-estimated the magnitude of the fault. On the other hand, if the strata could be correlated, then he failed to see why it was impossible to identify the "Rock Fawr" with the "No. 3 Rhondda" seam.

He had great confidence in the correctness of his correlations, as also in Mr. Birbeck's estimate of the magnitude of the Moelgilau Fault, in the Garw Valley.

He would suggest that the discussion of his paper might be conveniently closed at that meeting.

The PRESIDENT said that in a case where an immense fault of that kind occurred, the dislocation would, of course, be considerable, and although seams of coal might lie within ascertained distances of certain rocks, there was ample room for them to be changed in character: that is to say, one seam of coal might be a very few inches in thickness and represent the true "No. 3," as in that instance, and another seam might be greatly increased in thickness and altered in character, and it was quite possible, if the distance were properly measured, that they would correspond to some extent. But with regard to those two seams, he did not see any characteristics common to both, except in this respect, that "No. 3" lay in a great thickness of the Pennant rock, and that the "Rock Fawr" also lay in a similar thickness of the Pennant rock. In other respects, he did not think he could alter what he had before said, namely, that it was quite possible that the seams might be changed in character, whilst at other times, they might apparently keep the same position, but be entirely different in character.

Mr. T. J. Price said he thought his friend Mr. Jordan did not seek to identify seams by tracing them from one pit into another, or from one district into another, but rather upon broader principles. He found in one place a rock of a remarkable character, and immediately overlying that a seam of coal, above which he found two other seams of coal, and above a mass of Pennant rock. Going down below that first rock he found, in a few yards, a seam of coal, and below that two or three seams of coal. That was on the south crop. Then he went to Maesteg, and there found the same conditions presented. The same rocks, the same seams overlying, at corresponding intervals, and at the top the same great mass of Pennant rock, and below the same seams of coal and the same conditions repeated. He thought the correlation which Mr. Jordan had brought forward explained the phenomena better than any other, but when he (Mr. Price) first came to the district he did not hold that view; he then thought the "Rock Fawr" was higher up in the measures than "No. 3." The correlation did not depend upon the similarity of the seams, or upon their thicknesses, but upon the general geological character of the strata, the identity of which was not affected by faults or other disturbances subsequent to deposition. He did not say that any particular seams were continuous over a large area of country, but where there was a large mass of rock like the Pennant, the conclusion was irresistible that any particular seam found associated with it must be one of the series belonging thereto, and collateral evidence should indicate which.

Mr. Green, who did not know the district the Paper referred to, agreed with Mr. Price that the comparison of the rocks and stratification afforded a safer guide than any comparison of the seams themselves. He thought it would be a great aid to the better identification of the various seams if a careful record were kept of all new sinkings, and of the strata passed through. He had recently sunk two shafts in the district through 60 yards of Pennant rock to the "Black Vein" seam, and had carefully kept specimens of every bed they had passed through. If such

specimens were kept in every district, it would greatly aid in elucidating the question.

The discussion on Mr. Jordan's Paper then closed.

In the absence of Mr. George Birbeck, the discussion of his Paper on "The Bryncethin and Ogmore Valley Mineral District" was postponed until the next meeting.

ADJOURNED DISCUSSION ON "COAL WASHING."

The PRESIDENT said that the next Paper for discussion was one by himself on "Coal Washing," and he should be glad to hear any observations upon it. He might remark that there was a Paper down for reading that day on a similar subject, upon which the discussion would be opened at the next meeting.

Mr. J. M'MURTRIE said that the impression which he had formed from reading the discussion that took place at the last meeting, was that there was a want of definite information as to the results by Mr. Sheppard's machine. They wanted careful statistics as to the percentage of settlings, with the kind of rubbish drawn out, which did not appear either in the Paper itself, or in the discussion. That was a point to which he hoped more attention would be given. But he was interested in it from another point of view, and that was that the water could be used over and over again for cleansing the coal without allowing a large waste to flow away to pollute the streams. He thought that was one of the most valuable features in Mr. Sheppard's washing machine. He instanced a colliery which was working a very dirty seam, which necessitated washing the coal, and one thing after another was tried to remedy the difficulty of

dealing with the waste water, which, finding its way into the streams, damaged a rich agricultural district to such an extent that the washing of the coal had to be abandoned.

Now, any system of coal washing that would remedy such a state of things, and wash the coal without fouling the natural streams, was well worth their attention, and he considered that sooner or later the question would be forced more upon their attention than it was now. It was contrary to law to foul a brook in any way, and although it had not been enforced against the coal owners in South Wales as it was in more open agricultural districts, yet as time went on it would force its way more to the front, and make the principle of Mr. Sheppard's washing machine all the more valuable.

Mr. J. T. EDMONDS wished to ask whether Mr. Sheppard could state the size of pipe required for the operations of a one, two, or three-bash machine, for they had been told that "only a small quantity of water" was required, but the actual quantity had not been stated. He assumed that the head, or pressure, would not as a rule be excessive. Also whether, from the experience he had obtained, he could state what was a safe aperture at which the rubbish valve should remain open? It was generally left to the discretion of the workmen to regulate the valve, and the result was that one man thought it should be so much, whilst another man would have a different view, the result being either that a quantity of coal was carried off with the rubbish, or a quantity of rubbish went over with the coal. In one machine he had examined, and which had been made by Mr. Sheppard it was found that no shale was allowed to escape with the coal, and in that case the rubbish valve was open one inch. He should like to know if that might be taken as a safe average opening.

Mr. SHEPPARD said he could not give the exact quantity of water required for a one, two, or three-bash machine, as he had not been able to ascertain it definitely. With regard to the rubbish valve, he thought it was necessary that it should be left

to the judgment of the workman, because it had to be varied according to the amount of coal passing through the machine, and the quantity of dirt in the coal washed.

In the North of England, when coal was passed through a quarter-inch screen, the opening of the valve was very much smaller; in other cases where the coal was in pieces of six or eight cubical inches, the opening of the valves had to be very much larger; besides which, the valve was not required to be open at all times. The great thing to be attended to was to keep about three or four inches of shale upon the sieve bottom, and it was better that there should be rather too much shale than too little. The valve must be opened as the shale accumulated, and not be kept open continually. He had found no difficulty in getting the men to attend to it properly.

Mr. E. P. MARTIN said that at Blaenavon it was found that even the different veins of coal required different openings of the rubbish valve. Some of the shale broke into large and flat pieces, and did not pass easily through the small opening, but when the shale was smaller the opening could be reduced considerably.

Mr. JAS. M'MURTRIE said that in the discussion at the last meeting a good deal turned upon the proper time for crushing the coal—whether before or after the coal was washed. It appeared to him that an advantage would arise from the combination of both principles. There was a disadvantage in passing coal through the rolls, first, because the shale was ground into a fine pulp, whilst, on the other hand, if that were not done, the pyrites would not be taken out. It seemed to him that there should be a preliminary washing to remove the shale, and that the coal should then be passed through the rolls, and afterwards again washed to remove the pyrites.

Mr. E. P. MARTIN thought it was a difficult thing to say at which period of the process it was best to crush the coal for washing. He had, however, come to the conclusion that the best way was to separate the coal into the different sizes for

washing, taking care only to crush the coal that was large enough to require crushing, and so avoid making more dust than was necessary, for he found it was practically impossible to wash dust coal. He thought if the largest portion of the coal that was brought to the machine were first screened, and afterwards crushed, that the small coal might be passed into the machine without being crushed at all, so as to avoid making more small.

Mr. T. J. PRICE said the Paper under discussion was on "Coal Washing," reference being made incidentally, by way of illustration, to various machines, and from that point of view they had full information; but if the discussion were to be taken as relating principally to Mr. Sheppard's machine, then they were certainly confronted with the difficulty that none of the details had been presented which would enable the subject to be fully discussed.

In dealing with the subject he was consequently obliged to do so upon hypothetical grounds. In the earliest examples of Mr. Sheppard's machine he used catchponds pure and simple, but in the later machines a great stride had been made in using the water continuously without an interval for settling, and he considered that that step was of questionable advantage.

By the arrangement which had been adopted the water went coursing round and round and was at all times charged with impurities in suspension, and probably also in solution, to the maximum extent of its ability to hold it. At any given down-stroke of the plunger the water was forced through the dirty coal to be washed; it emerged surcharged with impurities which it deposited freely at the first opportunity; the surcharged water was thus allowed to settle over the washed coal, and there must be a deposit of impurities on the washed coal.

In washing coal charged with pyrites there was a deposit in the channel leading from the coal to the first catch pond, that was to say, at the first opportunity, hence he thought there must be not only a deposit on the washed coal, but a deposit of the

most objectionable character. He would be glad if attention were directed to this particular defect, and he must not be taken to be speaking adversely of Mr. Sheppard's machine because he differed on this point; on the contrary, he freely recognised the valuable nature of some of the arrangements.

It would be interesting if it were stated authoritatively what was the total quantity of coal washed by one of his machines, with the proportionate weight of clean-washed coal, and of the earthy deposit, say of 100 tons of coal passed into the machine, how much would result as clean-washed coal, and how much as spoil or rubbish, and the constitution of the spoil. At page 112 he went to the essence of the subject, when, in speaking of the machine, he said there was less shale mixed with the washed coal and less coal mixed with the shale. Now that was an important statement, and if Mr. Sheppard could make it good he would be making a great stride. He must say, however, that he read it with some surprise, as it did not accord with *a priori* considerations, or accord with their knowledge of washing coal. Nor did it agree with the statement that it took 2 tons of unwashed coal to produce 1 ton of coke. If Mr. Sheppard would address himself to those points, and give the information required, he would be speaking to neither captious nor inattentive hearers.

At the April meeting the President said he found the modified washing machine of Mr. Sheppard washed coal with the greatest success. This no doubt was correct, but he was inclined to think that that success was not because of the continual using of the water without an interval for settling, but in spite of it. There was a regular delivery of coal into the machine by the elevators, which was of much importance to insure successful washing, whereas in the old machines, which were fed direct from the screens, the coal was delivered with great irregularity. Sometimes the elevators came up empty, there being no coal, and the resistance being thus removed the machine quickened in its action, and the water obtained too high a velocity and carried over some

of the shale with the coal; but in Mr. Sheppard's machine, which was not fed directly from the screen, the coal was washed cleaner because it was delivered with greater uniformity to the machine. He had derived much pleasure from reading the paper, which he considered dealt with one of the most important questions which could occupy their attention.

The PRESIDENT said that his paper had been discussed most thoroughly, but he wished to observe that it was not intended to especially advocate Mr. Sheppard's machine, or any other particular machine, but he thought the question of clean and pure fuel was one which was of the utmost importance in connection with the iron works, for it has enabled a large increase in the make of a furnace to be established—so great indeed as to increase the yield from 140 tons per week to something over 430 tons, which he need not say could not have been done with anything but very clean fuel.

Taking the principle of washing, or the separation of coal from its accompanying shales and pyrites by means of water, similar results could be obtained by the trough or machine washing, and the question whether the coal was conducted a long distance or a short, and whether the purest coal was deposited in the nearest settling place or in the furthest, and the economic results of the different systems, depended on many circumstances. He would therefore prefer to ask what was the particular result of dealing with a particular vein of coal extending over a long period, so as to get the average result of working? The machine or appliance used for that purpose would then have been set suitably for that particular work, and would therefore bring about the greatest economy.

There were several points which naturally arose in dealing with the different classes of coal in the same machine. In respect to the crushing, the different coals containing ferruginous pyrites, which was frequently distinctly marked in the cleavage of the coal, and in other cases associated as balls, or nodules, commonly called "brasses," and sometimes also in very small

grains. One class of coals would require crushing before washing, the other would not require so much crushing because the natural cleavage would assist the separation of the pyrites. So that it was necessary to consider carefully the characteristics of the class of coal to be washed, and to determine the best mode and time for crushing.

With regard to the use of the water over and over again, he thought it was of little service to discuss the question from a theoretical point of view; practically, if the water became surcharged every time, it would become at last too thick to be used, but to that, Mr. Price said it deposited the *débris* with which it was surcharged, at the first opportunity, and that was immediately after each upflow of the water had lifted the coal upon the sieve. He was sorry he could not present the exact figures, but so far as could be ascertained, the resulting coke was practically the same as if the water were running away to waste, and that, he thought, was the real practical solution of the question; and he had come to the conclusion that the water could be used over and over again with very good results.

In respect to the desirability of crushing coal, there could be no doubt that the finer it was crushed the better the result would be in the density of the coke. That had been proved from careful experiments. But on the other hand, when the coal was ground too small it became very difficult to separate it thoroughly in the machine. Fine ground coal required a much longer time to wash, and it became important not to overwork the machine, and to make the deliveries as regular as possible, and allow a very much larger margin to the machine; but if the coal were fine, and the water completely drained from it before it was put into the coke ovens, the product was a coke of much greater density, which, for distant shipments was of material importance. In one case that he could refer to, the coke on arrival at a foreign port had to be carried upon mules' backs for a long distance, but it was so dense and hard that there was no sensible depreciation from breakage.

Mr. E. P. MARTIN asked what plan had been found best for screening the coal, because the proper division of the coal was, in his opinion, a *sine qua non*. He had tried cylindrical and the straight bar screen, but could not screen small coal at all successfully when it was wet.

The PRESIDENT said that the screening appliances depended upon the class of coal to be treated. Coal with a cubical fracture did not require a cylindrical movement, but the steam coal of the district was best dealt with by passing it over a rotatory screen. Damp or wet coal was always difficult to screen, and he did not see how any variations in the screen would enable it to be done successfully. The only way to get over the difficulty, was to effect a separation by means of water, carrying the coal through various sizes of screens, which would effect the separation perfectly; the coal was raised and as it were jigged up through the various sieves or screens by means of the water, the large coal would not go through the first sieve or screen, the lesser size lumps were intercepted by the next, and so on in rotation, the small, fine coal being on the last sieve, and in that way the coal was thus easily and perfectly separated into the different sizes, and he thought that was the only way in which wet coal could be treated.

Mr. J. T. EDMONDS could not help thinking that the day was approaching when coal would be "washed" without water at all; that is, that the separation would probably be effected by means of air instead of water.

Mr. G. J. JEE asked if Mr. Sheppard could give an idea of the quantity of water required for each machine. He had occasion to recommend a machine of the kind, and the first question asked was, what water did it require? Generally at the works in South Wales there was not much water to spare, and consequently the quantity required was an important question. If the size of pipe required for a machine of that kind were given, it would be a sufficient guide to estimate the requirements.

Mr. SHEPPARD said he was sorry he could not give the size of the necessary supply pipe, but he should say a pipe of three quarters of an inch in diameter with, say, three feet head of water would keep a machine of 200 tons running all day.

A vote of thanks was unanimously accorded to the President for his Paper, and the discussion was brought to a close.

No remarks being offered on Mr. G. J. Jee's Paper on "The Cwm Carne Reservoir," the discussion was taken as closed.

The discussion of Mr. Wilkinson's Paper on "Tubbing Shafts and other Colliery Work," was, in the absence of the author, postponed to the next meeting.

DISCUSSION ON THE "MINER'S LIFE PRESERVER."

The PRESIDENT said that the next subject for discussion was Mr. A. Upward's Paper on the "The Miner's Life Preserver." For his own part he hoped that no necessity would arise for using any apparatus of that character in the district; he hoped the collieries would be so well conducted and looked after that an occurrence like the drowning at Tynewydd would not occur again; and that due caution would be used in approaching old goafs in workings, whether likely to contain water or gas, or not. They had had lately to record the terrible explosion in Scotland and the loss of a great number of lives, through approaching an old working carelessly. No doubt under some set of peculiar circumstances, such as those referred to in the Paper, an apparatus of the kind would be useful.

Mr. J. T. EDMONDS said that the apparatus was perfect theoretically, but the great difficulty that would have to be encountered would be the utter impossibility of making a joint, owing to the "breaks" in the coal. They all knew the character of the situations in which the machine would probably require to be used, and great difficulty would arise in forming a perfect joint between the machine and the face of the coal, which to be of any service must be air-tight, and he thought practical men would agree that it would be almost impossible to make it. Mr. Upward had promised to consider that point, and if the difficulty could be overcome he believed he could bring the machine into effective operation as easily as the model was worked.

Mr. JAMES M'MURTRIE did not agree with Mr. Edmonds as to the difficulty in forming a joint between the machine and the coal. When it was remembered that great pressure had to be contended with in tubbing, he saw no insurmountable difficulty in making a good joint. He considered that a far more serious difficulty had been pointed out by Mr. David Thomas at the last meeting, in boring the large hole through any thick barrier of coal of sufficient size to admit a man. He thought that would be an insuperable difficulty unless special machinery were provided.

With regard to the suggestions in figures 1 and 3 of Mr. Upward's Paper, he confessed he had met with occasions in his own experience when they would have been useful. During the past nine months it had been necessary to bore a hole through a barrier of shale to a drowned out drift, and unfortunately, two men had been lost in doing it. The hole was driven through successfully, but the water in the drowned out drift was highly charged with a poisonous gas, and when the hole was broken through, the men lost their lives before they could get in the plug. In that case, Mr. Upward's machine would have been of much value.

There was something useful also in the suggestions which he

had made that there should be a depôt, where a series of machines and tools should be kept available at any moment, for a large district like South Wales. Many things might have been avoided at Tynewydd if such a provision had existed. He thought the Paper should not be lightly passed over, for it deserved the careful consideration of the members.

The further discussion of Mr. Upward's Paper was then adjourned to the next meeting.

DISCUSSION ON "SAFETY LAMPS."

The PRESIDENT said that the next Paper for discussion was that on "Safety Lamps," by Mr. W. E. Teale.

Mr. J. M'MURTRIE said he wished to ask whether in South Wales any one had his attention directed to a substance met with on the wire gauze of new lamps? Some years ago he had charge of a fiery colliery, and the overman drew his attention to the fact that before using a new lamp he put the gauze of the lamp into a fire and allowed it to get red hot. He said it was coated with an oily substance, and showed him a piece of new wire, which, when put into the fire, threw off a slight flame. That, he thought, might be a source of danger if it were not removed previous to using the lamps.

Mr. HENRY K. JORDAN mentioned that the phenomenon was noticed in the Report of the Lamp Committee of the North of England Institute of Engineers. It resulted from oleaginous matter adhering to new gauze. On the gauze being heated to redness a second time the same results did not follow.

Mr. J. M'MURTRIE said he had mentioned it to Mr. Greenwell, who had called attention to it at the North of England Institute at the time he stated. He referred to ordinary wire gauze, and not to copper wire.

Mr. E. P. MARTIN asked if it would not be the oil used in drawing the wire. Oil or fat was used in that process.

Mr. J. M'MURTRIE said it was a substance which gave off a slight flame when put into the fire. He thought Mr. Martin's explanation was probably the correct one.

The PRESIDENT regretted that he had not been able to get any information, as he had anticipated, with regard to the application of the electric light to coal mines, but he had been informed that the application of electricity to mines could be so made that it could be applied throughout the principal places of a colliery—for instance, along the main levels and headings, and roads, or even to some of the stalls. It could not be applied to repairing work and setting timbers, but where a man was cutting coal for so many hours, and another man came in afterwards to fill it, the light could be put in such a position as to supply a light equal to gas light, and be perfectly free from danger by explosion.

If the men attempted to open or meddle with it, the connections would simply become detached and the light would be extinguished. He thought it would be an important thing if the mining engineers all over the world were to adopt it. He regretted he was unable to add more at that time, but it was an important subject, and he trusted it would shortly be brought fully before the Members.

The discussion of Mr. Teale's Paper was then adjourned to the next Meeting.

DISCUSSION ON AN "IMPROVED FIRE-BAR."

The PRESIDENT said the next Paper for discussion was one by Mr. Moxham on an "Improved Fire-Bar."

Mr. M. MOXHAM said that his attention had been drawn to the question in consequence of the difficulty in large towns of getting rid of the smoke nuisance. He had tried various means

by using different coals in various ways, and in almost every instance had found a certain amount of difficulty.

The "fire-bar" was a very simple contrivance. It had three advantages :—In the first place, it removed the difficulty of the smoke nuisance ; in the second place, it enabled anthracite coal to be used, which though, perhaps, a point not commending itself to those living in the eastern part of the county, was, nevertheless, a matter of great importance in point of economy ; and in the third place, the fire was more under control, more easily stoked, and he thought less clinker was produced, whilst the combustion was more perfect.

The construction of the 'Improved Bar' had been shortly explained in his Paper at the last meeting, and was shown in the sketch. He found, by using those bars, that, practically, no smoke was produced when burning either steam coal or anthracite, and that there was a saving of about 15 per cent. in the amount of fuel consumed. It was possible that in some boilers there might be a little more or a little less, but as far as he had tried it there was a saving of about 15 per cent.

The principle of the fire-bar consisted in its being made hollow, so as to form a channel or pipe for a current of air which was forced through it and which issuing by small holes near the top of the bar, passed through the burning fuel. The air was forced through the bars by means of a fan, or by a Körting steam-jet or blower, the latter being the simplest and most effective. In using the hollow fire-bars, the ash-pit was closed, and all the air was forced through the bars, which were thus kept cool and appeared to be but little affected by the fire, so that a considerable saving arose in the cost of maintainance.

They had made no difference in the form or use of the bars in burning anthracite or steam coal, and had used the same draught for both coals. They had tried both descriptions of coal, but could not discover that there was any great advantage of one over the other ; but they had found that with bituminous coal the hollow bars did not answer so well as with the other coals, as the bituminous

coal caked, and there was not the same freedom for the air to pass through the fire.

With the hollow bar and improved air draught they were able to use small steam coal, or anthracite, or any inferior coal. He thought probably that one of the places where it would prove of much advantage would be on board steamboats, because the space occupied by the boilers was always limited, and the stokehole exceedingly hot, whereas by using the hollow bars there would be little or no stoking, as the air coming through the fire-bars would keep them clean and the stoker would simply have to throw on more coal occasionally.

The PRESIDENT said that he could quite conceive that the admission of the air through the body of the fire, and its distribution in minute quantities, would lead to the more perfect combustion than if admitted over the top, or in large quantities through the fire itself. The admission of air in a proper manner was of great consequence, because if more air was admitted than the coal would absorb in combustion the temperature would be reduced, and he thought that the distribution of air through the fuel would be effected most thoroughly by the improved fire-bar.

In some trials that he had conducted for testing coals on a locomotive, he had great difficulties in that way, for he remembered the coal was put on in large quantities, and though the appliances worked accurately and new fire-bars had been put in, still the coal would not do its duty until the stoker was told he must put the coal on thin and the draught be allowed to come in under the fire. As soon as that was done the fire burned clearly, the fuel did its duty well, and there was abundance of steam, showing that if the air were distributed through the body of the fire it was the means of producing the best results. He thought it was better to apply the air through the fire than to pass it over the top. The air was better distributed in that way, and for steam coal it was an advantage which experience dictated.

Mr. J. M'MURTRIE said that the fire-bar under consideration reminded him of another invention by Prideaux designed to effect a

similar purpose. It was very simple, consisting of an apparatus in front of the door resembling a Venetian blind, which opened and closed to regulate the air admitted to the fire, as it required a greater or less supply. The principle that governed its action was that when the coal was put on fresh, it required a larger supply of air to consume the smoke, but if the supply of air were continued in the same quantity, it resulted in a loss of heat. He had seen the apparatus at work most successfully, effecting a complete combustion of the smoke, and had frequently seen it tested while the smoke was passing from the chimney in a black cloud, when, on the apparatus being applied, the smoke completely ceased, and the supply of air was afterwards gradually decreased until the fire became a red heat. He also remembered a fire-bar of somewhat similar construction being used at a colliery; in that case the bar was hollow, and water circulated through it instead of air. It had great advantages in durability, but not to the same extent, he thought, as the bar in question.

Mr. W. G. M'Murtrie asked what means were employed for forcing in the air. Mr. Moxham had stated that he used a steam jet for the purpose. He would like to know whether he had made any comparisons between the old form of bar and the hollow bar, and the character of the coal used at the respective trials, and what results had been obtained both with the anthracite and with the steam coal, so that it might be known whether there would be advantages of a substantial character by the adoption of the improved hollow bars with air blast.

Mr. James Murphy said that this bar formed an important addition to the different forms of fire-bars that had been invented. He remembered many hollow bars and bars with slits for applying air to the bottom of furnaces. He hoped that the bar introduced by the Paper would be a valuable contribution in regulating the combustion and concentrating the heat; but with the bar in question, as well as all the others, it depended much upon the attention of the man in charge, by proper stoking, to produce the best results. With reference to the combustion of smoke, it

appeared to him that passing air through the bar was beginning at the wrong end. In all smoke-consuming apparatus the admission of the air over the fire tended more to consume the smoke than if it were admitted through the fire-bars; and the application of the steam jet was evidently an important feature in the success of the hollow bar, because a steam jet introduced into the fire would produce a certain amount of advantage depending upon the chemical decomposition of the steam. He had tried many experiments, with reference to the admission of air to ordinary fires, and in one no air at all was admitted through the fire, but it was allowed to pass over the surface of the coal, and good results were obtained. In the furnace anthracite coal did not clinker like the bituminous, and that would be an advantage for the hollow bar—in allowing the air to pass freely through the fire-bars into the fire. When a heavy charge was put on a fire, the heat was blocked down, and therefore there was no radiation of heat, but if the fire began at the top, the whole surface of the coal would be exposed, and if it be made to burn from the top downwards it would yield better results, in the economy of house fires.

Mr. M. Moxham said he agreed with the proposition that a new invention was generally better looked after when first introduced and until the novelty wore away, but he thought that the advantages offered by the improved fire-bar were such that the man had not to pay so much attention to his fire as he would have been accustomed to give before. In the ordinary furnaces a man must be always attending to his fire, but the stoker, when the improved fire-bar was used, had nothing to do except to put on coal occasionally. He had no lifting or raking except at the end of the day, or in the morning to rake out the clinkers, and it was a great advantage that a man had not to pay so much attention as he had with the ordinary bar.

Anthracite coal had less clinker than ordinary coal and less ash. Although, apparently, there was an impression that locomotives should be chiefly supplied with air admitted

over the fire, yet it must be remembered that there was also a large quantity allowed to pass up under the bars. In the hollow bar, however, it was not allowed to pass up under the fire, but the whole of the air was passed through the bar and thence into the body of the fire, by which it was found that less coal was used. Steam was generated with greater ease, the smoke was all consumed, and a great economy effected by admitting the air through the improved hollow fire-bars.

Anthracite required a larger amount of draught than other coal to be used economically, and therein lay one of the great advantages of the hollow bar; for if anthracite could be thus brought into more general use it would be an important event, as it was a better fuel for many purposes. But until the introduction of the hollow bar it was difficult to burn economically.

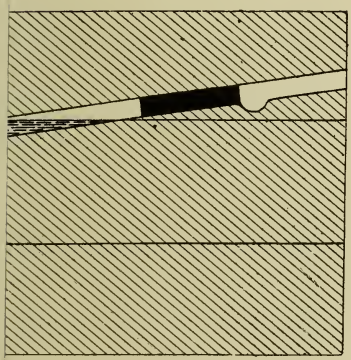
In respect to Mr. M'Murtrie's question, the air was driven through the bars by one of Korting's steam jet-blowers, which worked very effectively. The air was not heated to any extent in passing through the bars, but was quite cold as it passed into the fire.

Mr. J. R. Waddell said that if it were necessary to use a larger proportion of large coals for this bar than was usually required when using the ordinary bar, the difference in cost would show no economy in favour of the hollow bar.

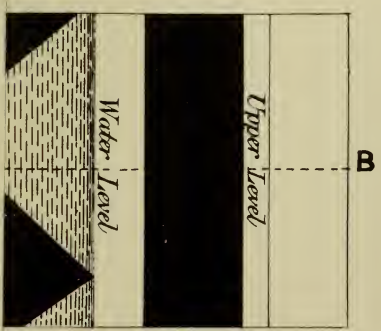
Mr. Jas. Murphy said that the practical question was whether any material saving could be effected by the use of the hollow bar in the manner suggested, and he thought it was desirable that careful experiments should be made, and the results communicated to the Institute, of the comparative economy in the working of the improved hollow fire-bars with that of the bar ordinarily in use.

Mr. Moxham said that he had used the hollow fire-bar with both small or nut steam coal and nut anthracite, and found that there was a saving of 15 per cent. as compared with using the ordinary bar when burning small or nut coal. Besides which, the same amount of heat could be obtained with a shorter fire-bar, and

PRESSED AIR.



VELS.



A. Reid, Newcastle on Tyne

PLAN OF TYNEWIDD INUNDATION,

Illustrating Mr. W. Galloway's Paper

on

EXCAVATING UNDER WATER BY AID OF COMPRESSED AIR.

FIG. 1. SECTION ON LINE A B OF PLAN.

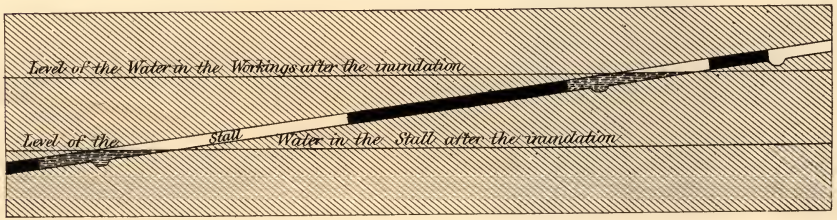


FIG. 2. PLAN SHEWING THE STALL & THE THREE LEVELS.

(Proceedings S.W.Inst.Engs.1877) N°6, Vol.10.

A.Reid, Newcastle on Tyne

perfect combustion being ensured all the coal was consumed, and instead of having the fire 8 or 10 inches thick, the same work was done with a fire 6 inches thick. He had two boilers fitted with the hollow bars, and had had them in use for some six or eight months very satisfactorily. He had brought a bar to the last Meeting which had been in use some fifteen months, and it was then as good as when it was put in, and, like the steel rail, it had so long a life that he had not yet seen one worn out; and for some time to come he would not be able to say how long it would last. He would be glad to make the experiments referred to by Mr. Murphy, as the consumption of coal was a very important question.

The PRESIDENT said that the question of admitting the air at the top or the bottom of a fire in sufficient volume to consume the coal was of much importance. In locomotives and furnaces it was required to force the fire as much as possible, and obtain that immense heat which rapid combustion brought about. Therefore, the more intimately the atmospheric air was mixed and brought in contact with the incandescent coal the better; and he therefore said, the idea of introducing the air through the hollow fire-bar into the fire was better than introducing it at the top, or underneath the bars.

In deference to the promise of further information made by Mr. Moxham, he thought it would be well to adjourn the discussion to the next Meeting.

The PRESIDENT said that Mr. Galloway's Paper, "On Excavating below Water-level with the aid of Compressed Air," was next on the list for discussion, but that gentleman had written to say he could not be present; the discussion would therefore be adjourned to the next Meeting.

The SECRETARY then read a Paper by Mr. Galloway on "The Firedamp Cap."

ON

THE FIREDAMP CAP.

By W. Galloway.

If a miner's lamp or candle, having a flame of ordinary dimensions, be placed successively in an infinite variety of mixtures of air and firedamp, then in all mixtures containing less than a certain proportion of firedamp, it will appear to burn in the same way as it does in pure air, and in those containing more than that proportion, but less than sufficient to render them inflammable at ordinary temperature, it will give certain indications of the presence of the firedamp, which are more or less familiar to most persons connected with mining in the Coal Measures. It is therefore evident that, if we know the composition of the mixture which first visibly affects the flame of a lamp, we can always ascertain in an approximate way, by means of this test, whether any given atmosphere *contains more or less than the same proportion of firedamp;* and, since the indications become more pronounced as the proportion of firedamp increases above that amount, we can likewise tell whether the air of a mine is *nearly inflammable or not.*

At first sight, then, this subject would appear to be an important one to the coal miner; and one would naturally expect to find a good deal said about it by writers on mining subjects. The following quotations from the works of some of the best authorities will, however, testify that this is not the case; and, moreover, they will make it tolerably clear that the description

of Sir Humphrey Davy's experiments is the real source from which most of them appear to have obtained their information, directly or indirectly, although this is not acknowledged in every case :—

In the description of *Grubengas* and *Schlagende Wetter* which is given in Lottner-Serlo's "Bergbaukunde," 2 Aufl. II. Bd. 1873, the following passages occur at p. 196 :—

"According to the observations of Davy, who made them with the safety lamp which bears his name, the presence of firedamp first visibly affects the flame of the lamp when the air contains 1–30th of gas ; the phenomena intensify until a mixture of air with 1–15th of gas is reached ; the atmosphere becomes inflammable ; with 1–14th the flame is propagated throughout the whole mass, but without strong detonation."

"Phäler gives the following results of experiment :—With one volume of light carburetted hydrogen and 30 volumes of atmospheric air, the flame of the lamp becomes lengthened and drawn out to a fine point ; up to this point there is still no danger for the workmen ; with one volume to 15 volumes of air the flame is lengthened still more and begins to burn easily with a pale blue flame ; with one volume to 12 volumes of air the first slight explosion occurs ; this mixture is easily recognisable within the gauze of a safety lamp."

In describing protocarburet of hydrogen, Mr. Herbert Mackworth[1] says : "It burns in the air with a pale blue flame, giving very little light, and produces water and carbonic acid ; when it is mixed with atmospheric air in the proportions of 1-30th to 1–15th of the whole volume, the flame of a lamp plunged into it lengthens and enlarges itself, always more as the proportion of gas is greater. The flame of the wick appears to be surrounded with a halo of pale blue which is mainly visible at the point, but the combustion does not extend beyond that. On the contrary, if the carburetted hydrogen forms 1–14th of the whole volume the inflammation is propagated but slowly through the whole gaseous mass."

[1] *Lectures on Mining*, delivered at the Bristol Mining School. 1857, p. 71.

Smyth[1]—Firedamp or Light Carburetted Hydrogen.—"If mingled with air in the proportion of 1-30th to 1-15th, it may be detected by the 'cap' on the flame of a lamp or candle. If in larger proportions it becomes explosive. . . ."

Atkinson and Greenwell[2]—Dicarburet of Hydrogen.—"When mixed with atmospheric air in the proportion of 1-30th to 1-15th of the total volume, the flame of a candle plunged into the mixture is elongated as the proportion of gas approaches 1-15th of the volume. The flame of the wick is surrounded by a halo of pale blue, which is most perceptible towards the point. The combustion only takes place around the wick of the candle, and does not extend to the whole mass. When the firedamp forms 1-14th of the total volume the inflammation extends throughout the whole volume of the aëriform mass, but without detonation."

Hyslop[3]—Firedamp.—"Sir Humphrey Davey's experiments proved that. . . . . in 1 of gas with 10, 11, 12, 13, and 14 of air, the candle burnt with enlarged flame without exploding; but a gradually diminishing ratio was produced as far as 30 of air to 1 of gas."

Callon[5]—Le Grisou.—"The first phenomena do not commence to manifest themselves, or, as the miners say, the gas does not begin 'to show' (*à marquer*) until there is about 3 or 4 per cent. of it in the mixture. With 6 per cent. the flame is very elongated, and the aureola very full-blown. With 7 or 8 per cent. the propagation is gently transmitted through the whole mass."

The last writer, alone, does not define the *exact* limits between which the flame of a lamp indicates the presence of firedamp; the others are precise in this regard, and there is, besides, a remarkable uniformity in their statements. From this it might be inferred either that firedamp has a fixed chemical composition, or that, no matter how much its constitution may vary, it will

[1] *Coal and Coal Mining.* 1867, p. 204.
[2] Greenwell's *Mine Engineering.* 1869, p. 211.
[3] *Colliery Management.* 1870, p. 424.
[4] *Cours d' Exploitation des Mines.* Tome deuxième. 1874, p. 424.

always give the same results when mixed with the same quantities of air.

The author was first forcibly impressed with the anomaly in 1873 when he was conducting some experiments with safety lamps in a mine at Dollars' Colliery in Ayrshire. Being unable to obtain the results he had anticipated, he concluded that the firedamp was a very impure one, and for the purpose of applying a rough test, he made a mixture of it with air in the proportion of 1 to 13 volumes. This mixture was not only not inflammable at ordinary temperature, but with a lamp-flame $\frac{1}{4}$ inch high by $\frac{1}{4}$ inch in diameter at the base, it showed a cap of only $1\frac{1}{2}$ inch high. An analysis of this firedamp was afterwards made by Dr. T. E. Thorpe, who found it to consist of 75·86 per cent. of marsh grass, 1·31 per cent. of carbonic acid, and 22·83 per cent. of nitrogen.[1] Another instance of a decided departure from the fixed limits also came under the author's own observation while he was making some experiments that will be referred to presently. He found that a mixture of one volume of the firedamp that i used for lighting purposes at Llwynypia Colliery, and 15 volumes of air, was inflammable at an initial temperature of 57° Fahr. The composition of this gas, according to the analysis of Mr. J. W. Thomas, of Cardiff, is—Marsh gas, 94·78; hydride of ethyl, 0·90; carbonic anhydride, 0·72; and nitrogen, 3·60 per cent.[2]

Independently of the proof afforded by actual experiment, however, it might be predicted from a mere inspection of th analysis of any given firedamp whether the greatest proportion of air with which it would form an inflammable mixture would be relatively large or small; nay, further than this, if the temperatures of ignition and combustion of marsh gas were accurately determined, the exact proportion could be calculated.

Turning now to a consideration of the halo, aureola, or cap which envelopes or appears to surmount the flame of a lamp, we

[1] *Proceedings of the Royal Society*, No. 154. 1874, p. 441.
[2] *Journal of the Chemical Society*, September 1874.

conclude without hesitation that it is a phenomenon caused by the inflammation of the combustible part of the firedamp contained in the air which comes into immediate contact with the flame. The carbon and hydrogen of the marsh gas combine with oxygen to form carbonic acid and water. In order that this should happen it is not necessary that the air contain any definite proportion of firedamp, as under the same conditions the very smallest conceivable proportion is consumed. The mixture requires to be heated to the temperature at which a chemical combination of these gases takes place. But the flame of a lamp possesses a higher temperature than is required to effect this, and therefore, although we cannot see it, the halo begins to be formed as soon as there is the slightest trace of firedamp in the air. It cannot be distinguished from the outer so-called non-luminous zone of the oil-flame of which it forms simply an enlargement. As the proportion of firedamp increases the relative size or volume of the non-luminous zone increases also, until at length it visibly affects the shape of the luminous zone.

This is said to occur when the proportion of firedamp is 1-30th of the whole volume, according to the authorities already quoted. At this stage the halo is still invisible, but, as the proportion of firedamp goes on increasing it is said to become distinctly visible to the unaided eye. This statement, if unqualified in any way, would mean that any kind of firedamp and any quality of air ordinarily met with in mines would produce the same phenomenon.

The luminosity of the ordinary flame of a lamp or candle makes it difficult or impossible to distinguish the halo, at least in its earlier stages; and, quite recently, Mr. Steavenson, of Newcastle-on-Tyne, has brought forward the suggestion that a piece of blue glass should be held between the eye and the flame for the purpose of eliminating the dazzling effect of the yellow rays on the eye.

The object of observing the halo at all is always the same,

namely, to ascertain as nearly as possible what proportion of firedamp is contained in the air of a mine, or, in other words, whether the atmosphere is nearly inflammable or otherwise. It is a rough method, but also a ready one, and it has the incalculable advantage of being applicable with apparatus already in the hands of every miner. It is the case, however, in practice that not much can be learned from these indications of the flame of a lamp except the bare fact that the air is nearly inflammable or not, unless we make use of a standard flame, that is, one of a certain definite size or heating capacity, and compare the apparent volume of the halo or height of the cap produced by it under different conditions. In addition to this, however, if we wish to estimate the proportion of firedamp contained in any given atmosphere, we must be possessed also of a standard of reference consisting of data obtained by a series of similar observations made with the same size of flame in atmospheres of known composition.

Nothing appears to have been attempted in this direction until the beginning of 1876, when the author made a close study of the subject in connection with an inquiry he was then conducting into the inflammability of mixtures of air, coal dust, and firedamp.[1]

The experiments in which we are interested at present were made in the cabin near the bottom of No. 3 Pit Llwynypia with firedamp obtained from a pipe close at hand. The apparatus employed, and the method of measuring and mixing the required volumes of gas and air, are described in the "Proceedings of the Royal Society," to which reference may be made for information regarding them. The flame chosen for a standard one is produced by drawing down the wick of a safety lamp until the yellow part almost disappears, but is still represented by a central yellow speck near the top of the bright blue oil-flame. The latter is about 1-4th inch in diameter by 1–8th inch high, and its non-luminous zone is distinctly visible. The wick must be carefully trimmed

[1] *Proceedings of the Royal Society*, No. 168, 1876, p. 354.

and free from short loose fibres; indeed, it ought to present a smooth appearance on the top and be quite free from crust if small caps are to be observed.[1] Otherwise the non-luminous zone appears to be much enlarged in pure air, and may be mistaken for a small cap when there is really less gas in the air than can be detected in this way. In any case the flame must be carefully observed in fresh air as often as possible, so as to accustom the eye to measure the size of the non-luminous zone (with a clean wick it is not more than 1–16th inch thick), and enable it to detect the smallest increase due to firedamp. Small caps cannot be seen through wire gauze, and for this reason a glass lamp free from threads or flaws of any kind is to be preferred. The glass should, of course, be as clean as possible. The size and shape of the caps corresponding to mixtures of firedamp and air of the known composition were as follow:—

1 of firedamp and 16 of air: a voluminous, waving, spindle-shaped pale blue cap $3\frac{3}{8}$ inches high. (A mixture of 1 gas and 15 air was inflammable.)

1 and 18: a similar cap 2 inches high, which burned rather more steadily.

1 and 20: a cap $1\frac{5}{16}$ inch high, with nearly parallel sides to about two-thirds of its height, and drawn out to a point at the top. This cap was perfectly steady, and more distinct than any of the others.

1 and 25: a conical cap $\frac{1}{2}$ to $\frac{5}{8}$ inch high.

1 and 30: a conical cap $\frac{3}{8}$ inch high.

1 and 40: a conical cap $\frac{3}{16}$ to $\frac{1}{4}$ inch high.

1 and 50: an exceedingly faint cap $\frac{1}{8}$ inch high, the top having the appearance of being broken off.

[1] For the purpose of being able to trim a Clanny lamp in this manner without having to send it to a lamp station to be opened, the author designed what he supposed to be an original kind of wick-trimmer, consisting of a small ball and socket joint, with a hole in the ball through which a wire (bent at both ends to prevent it from being drawn out accidentally) could be manipulated with the desired effect. He ascertained afterwards that the same arrangement had been applied to another special kind of lamp by Biram in 1849, but Biram's lamp did not come into general use, and was lost sight of.

1 and 60: it was hardly possible to distinguish anything above the small oil-flame. If there was any cap (which the mannger of the pit and two of the firemen who were present during all the observations considered excessively doubtful), it was represented by the frustrum of a cone little more than $\frac{1}{16}$ inch high.

Figure 1 shows the form and size of the various caps from actual measurements and sketches taken at the time.

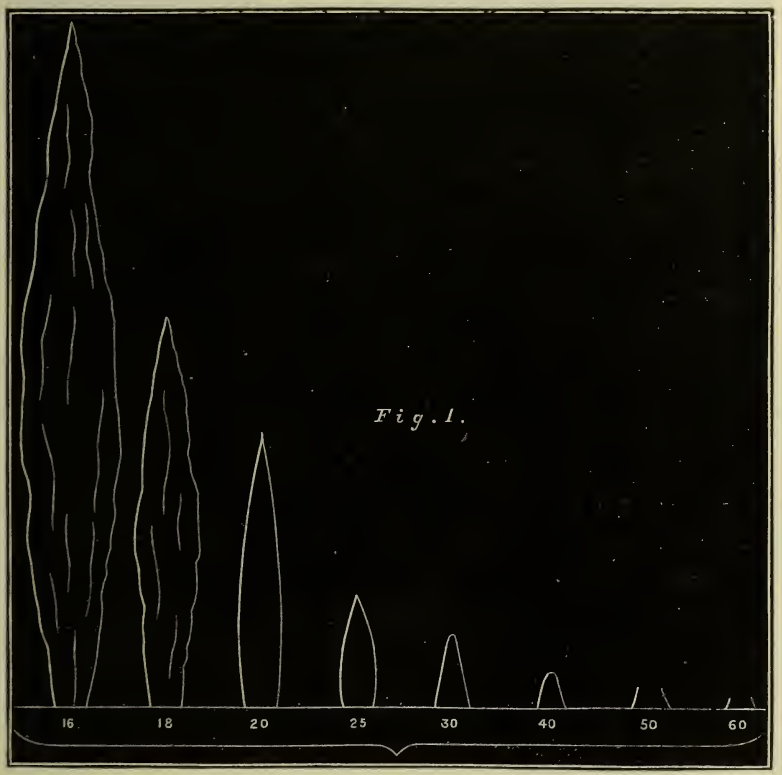


Fig. 1.

Figure 2 represents those results graphically. The heights of the various flames were shown by dotted ordinates; and the abscissæ, measured from left to right, corresponded to the number of volumes of air mixed with one of firedamp for each particular cap. The curve which had been drawn through the

top of the ordinate representing 20 volumes of air was a rectangular hyperbola.

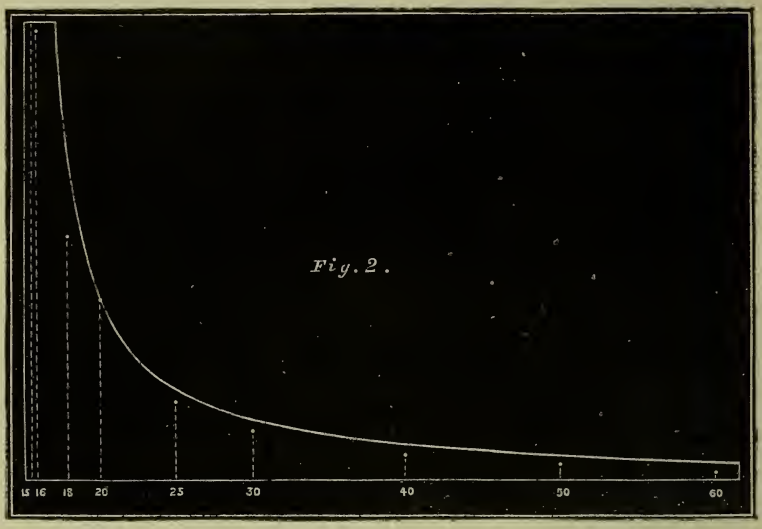


Fig. 2.

The following translation of some remarks made on the subject in a French periodical published in May last,[1] may be of interest.

The title of the article is "Le Grisoumètre de M. Coquillon" (M. Coquillon's firedamp measurer). The apparatus there described is a special kind of eudiometer, provided with a palladium wire for effecting the combination of the combustible gases with oxygen. The palladium wire can be heated to redness by means of an electrical current, and the combustion having been accomplished, the diminution of volume is read off.

"At Mons, M. Coquillon was accompanied into the mine by many engineers. It is well known that in order to estimate the amount of firedamp in the air of a mine approximately, the miners have only their own lamps at their disposal; in lowering the wick so that the yellow flame disappears, a smaller blue flame is seen, which is larger or smaller according to the composition of the surrounding atmosphere. It was desired to be ascertained whether the different kinds of lamps were comparable

[1] *La Nature*, May 5, 1877. No. 205, p. 357.

with each other; and for this purpose each engineer was provided with a lamp of different construction. Davy, Muesler, and *lampe du porior* (chèf mineur), and each observed the height of the blue flame at the same time that the air was analysed. The result was that the lamps were not comparable with each other, and could not give precise indications. The grisoumètre may perhaps make it possible to establish a lamp whose indications will be comparable."

According to the observations of the author, which have extended over a considerable period, the indications of any two Clanny lamps, with properly trimmed wicks and flames of the same size, are, as nearly as may be, identical.

The following Papers by Mons. H. Rivière (communicated by the President) on "An Improved Coal Washing Machine," and by Mr. G. F. Adams on "The Maesteg Tunnel," were taken as read, and ordered to be printed in the "Proceedings."

DESCRIPTION OF AN IMPROVED COAL-WASHING MACHINE.

By A. Rivière, Engineer.

(*Communicated by the* President.)

An attentive study of practical coal-washing, and of the arrangements in different washing machines, had convinced the writer that important improvements might be introduced into the mode of washing. For instance, he had not seen any apparatus combining the following conditions:—

(1) Moderate cost in its first establishment;
(2) Very low expense in motive power and in maintenance;
(3) Small supply of water;
(4) A large output, but variable at will, according to requirements, producing a large quantity of washed coal, or a smaller quantity with the minimum of waste;
(5) Washing coal of every kind, including the most slimy, which adheres in the hoppers;
(6) Minimum production of coal dust, which may, if necessary, be saved and even washed again with the coal in the washing machine;
(7) Very complete separation of the coal from the shale;
(8) Low net cost of the operation;
(9) Uniform and continuous production of washed coal.

His intention had not been to invent a washing machine altogether different from those already known, but to introduce into the better, and it may be said, general type, the improve-

ments and adjustments necessary to bring about as nearly as possible the desired results.

The study and the construction of the improved coal-washer having been completed, the experiments which had since been made had confirmed his views and realised his intentions. Four of these washing machines had been established at Alais, near the railway station of Tamaris, in the grant of Rochebelle, and the report read at the general assembly of the Compagnie des Mines, Fonderies et Forges, declared that the results had been satisfactory from the beginning. As more certain proof in favour of the system, it may be stated that other machines of a similar character are to be erected.

It is thought that the following description of this method of washing coal, and of the apparatus, will convince one that the results must be satisfactory.

As the title indicates, the washing machine is rather an improved one than a new one, that is to say, that although new in some of its arrangements and general composition, and in the special adaptation of its different parts, by which more advantageous results can be obtained, yet it is a composition, to a great extent, of other washing machines which have some analogy with it.

The descriptive list and the plans (Plate 23, figs. 1, 2, 3) will enable the apparatus to be understood. It will be desirable, however, to describe in detail the action of the machine, and call more particular attention to the gatework; the application of the special grating; the compartment for collecting the coal, with its lateral openings; the partition O; the compartments F, F; the position and arrangement of the clack valve G; the return of the water through a closed pipe outside the washing trough; the application of pulleys of several diameters in order either to regulate the rate of cleaning or the number of strokes of the piston; the arrangement of the screen of washed coal and the general arrangement of the whole, as the application or association of the different portions taken by themselves may present nothing new.

The apparatus has been constructed specially for coal washing, but by altering the dimensions and the form, it can be applied also to ores and other substances.

The body of the apparatus and of the piston may be constructed of wood, or sheet iron. In the engraving the body of the apparatus is represented as it should be when made of wood, and that of the piston of sheet iron. Anyone may choose for the different portions of the apparatus the material which is most suitable for the situation, and which can be supplied at the smallest net cost. Consequently, the dimensions and the details of construction would vary accordingly.

The water is introduced below the screen (the inclination of which is unlimited), or into the compartment of the piston, and the supply is regulated by a cock, or in any other manner; the coal, anthracite, or lignite enters by the hopper C; and the coal dust to be washed between the grating L and the gate K, in a sort of hopper formed by these two small portions.

By introducing the coal to be washed regularly into the hopper C, by any mechanical means whatever, or by a shovel, in small quantities at a time, the gate K may be entirely raised, and the washing proceed the whole length of the screen; if, on the contrary, the coal be supplied to the hopper in an irregular manner, or in large quantities at a time, the gate should be more or less lowered, according to the physical condition of the coal, in order to regulate the discharge from the hopper.

The grating L breaks up the agglomerations of small coal, facilitates the washing of the coal dust (which is caused to pass to the washing bash by being thrown behind the grating), and retains the chips of wood mixed with the coal. It is comb-shaped, formed of bars more or less close, which do not penetrate the coal too much, and may be applied to different systems of washing bashes.

The gate M, which is lifted or lowered by means of racks, like the gate K, increases or diminishes at will the thickness of the layer of coal submitted to washing on the screen. This gate

forms its moveable overfall, and extends the whole width of the bash.

The compartment D, which also extends the whole breadth of the machine, offers nothing remarkable. A worm *d* works in this compartment, which draws the shale into the compartment D″, outside the washing tank properly so-called, from whence it is carried away by a chain D′ furnished with buckets, or rakes.

The shale passes into the compartment D by the openings *d′*, which open or shut at will by means of a gate in groves, moved from the outside by means of a handle *d″*, which forms the extremity of a guide rod, sliding in a stuffing box, and fixed to the gate at its extremity.

In the tank E the grating N serves to retain the small chips of wood and other floating refuse which would pass through the grating L, which corresponds with it, with the exception that the bars of the latter are wider apart. At the grating N the bars may be replaced by perforated sheet-iron, or a simple cross board.

The partition o″, which, with the exception of the sloping of the sides in the upper portion, extends over the whole width of the tank, facilitates, in front, the deposition of the small coal with the washed coal, and prevents the chain buckets ever becoming overcharged with washed coal, which may be produced in excess at times. It thus fulfils the office of regulator for loading the buckets. Its lowest position must be determined by experience and by feeling.

The partition confines the agitation produced by the movement of the buckets. If the chain were not enclosed in a compartment, the agitation produced would continually raise the small coal deposited with the coal, and would prevent other small coal from being deposited; while once the coal dust is carried into this compartment, it has no issue by which to escape but by the chain buckets, the coal surrounding the open bottom of the compartment, and the openings *o′* permitting the small coal to pass into the compartment, but not to pass out, because there is no side current of water, or rather, because there is one

which passes from without into the compartment O to replace the water which is constantly carried away with the washed coal by the chain buckets. This arrangement is very effective in economising waste of dust coal.

The partition *e* extends over the whole breadth of the washing machine; it is carried a little higher in the compartments R and R′, than in the compartment O, where it is limited and continued by the separate bottom *e′* of the cage of the chain buckets, which rises on three sides well above the tank of the washing machine, as well as the exterior compartment D.

Between this partition *e* and the anterior side of the body of the washing trough there are two compartments—

(1) The compartment F, which receives the current of water in its upper part on two sides. That which passes through R (fig. 3) is received by the opening P′, and that which passes through R′ by the opening P (fig. 2), which is above the bottom *p* and laterally under the bottom *e′* of the cage of the bucket chain.

(2) The compartment F′ on the side of the pipe for the return water, which is separated from F by the continuation of the partition which limits the compartment R″. This continuation bears the clack valve Q (fig. 2). In the upper portion the compartment is shut by a moveable bottom *p* (fig. 2), which serves to fix and examine the valve Q, to which valve is added, at need, a weight to facilitate the shutting of it. For the same object the clack seating is so fixed that it deviates from the vertical plane.

When the piston is lifted, the suction produced opens the valve Q, and a current is established by the return water pipe I from the tank E, at the lower part of the tank A, under the piston B and the screen *a*.

When the piston descends, the pressure closes the valve; the repelled water traverses the screen, lifts the coal, classes it, and carries with it the upper layer of washed coal into the tank E, where it is deposited, and from whence it is lifted by the chain buckets into the hopper G, under which the trucks are placed to be filled.

The hopper is shut in front by a door hung on hinges, which is so arranged as to be opened at will, and can be shut by pulling a long handle when there is no truck below to receive the coal, which is thus thrown into the hopper for a time and stoppages avoided.

The position of the truck which receives the shale at the side of the washing machine is indicated in outline in fig. 1. If it were necessary, however, the shale or the coal might be conveyed to any point by lengthening the chain buckets and making them deliver at a considerable elevation into inclined troughs along which the coal or shale would be carried; or it might be allowed to fall into galleries established under the washing machine.

The driving pulleys of the chain buckets, and of the piston, are shown on the plans, together with the belts by which they are driven. For the belts may be substituted articulated chains, and cast-iron rounds for the pulleys.

As the production of the machine may vary according to the nature of the coal which is being washed, the number of the piston strokes, the position of the gates K and M, and from other causes, pulleys of different diameters, v, v', have been provided, in order to increase or diminish the relative speed of the chain buckets E', and the same might be done for the pulleys v', v''. The pulley V, which is attached to a loose pulley, receives the power for driving the washing machine, and the shaft which carries this pulley and the cam, may at times be conveniently made the driving shaft, in which case the pulley V would be useless, and the loose pulley would be by the side of the pulley V'' or the pulley V'.

When it is desired to stop the work of the piston without stopping the movement of the cam, the bolt y is drawn when the piston is at the bottom of its stroke, and the cock Z is lowered.

A speed of thirty to forty piston strokes per minute is a good medium speed for this washing machine.

The gate S' is especially designed to free the chain for lifting

the coal when it has become accidentally entangled; it serves also to empty the tank E when necessary, which is very seldom.

The gate S may serve to empty the muds from the tank A, but most generally it is preferred to let the muds accumulate in the tank, then to empty the water through a hole made below the piston in the back of the washing machine, and which is shut by a wooden plug. The water having run out, the door U is opened, and the muds are taken out with a shovel, and heaped aside, to be passed during working behind the special grating L. The gate T serves to empty the compartment F.

The emptying gates are controlled by means of a rod with screw and flyer.

At the end of the compartment F′ another small gate or opening is placed, shut with a plug, through which the water may be emptied from the tank A by the use of the return water pipe.

In short, when the washing machine is built on masonry, it is well to have a canal *h* round it to receive the water and muds which may escape, and to conduct them where desirable without soiling the place, and without fouling the muds. This canal may be utilised to wash the muds with a current of water.

In order to clean the return water pipe it is sufficient to open, more or less, one or other of the head joints; the escaping water cleans it sufficiently, especially if the introduction of water into the washing machine is continued for a few minutes, and if the deposited muds are stirred with a rod. It will answer the purpose simply to take out the plug of the compartment F′. In any case, in order that it may be easy to open and close the head joints, they are kept shut by eyebolts and keys. Besides, as this pipe does not get choked, there is no necessity to clean it for months together.

The machine produces most satisfactory and regular work with great economy in point of time, and has many special

advantages resulting from the mode of construction and arrangement of its different parts, particularly in respect to the following, which may be considered to be new appliances, viz.:—

(1) The use of the gates K and M, by which the quantity of coal, or other material to be washed, may be kept constantly in the conditions which may be most suitable to its nature whilst being washed, or by which the conditions of supply that may be wished for may be approached.

(2) The application of the special grating L and V, which allows the muds and the massed slimy coal to pass and be washed advantageously, and acts at the same time as a regulator, and retains the chips of wood and other floating refuse, which would lower the value of the washed coal, and which might also put the clack valve Q out of order.

(3) The compartment Q of the lifting chain, which not only prevents the agitation of the water, and thus allows the *small coal* to be deposited, but also draws it through the openings *o'* to be mixed with the coal.

(4) The position of the clack valve Q, which ensures its acting well, by sheltering it from the muds, and which allows it to be examined easily without even emptying the washing tank of water. Besides, even if the valve should not act, it would not interfere with the working of the machine, as experience had proved that the washing would proceed very well, even if the valve were removed. A current was set up, which did not become deranged.

(5) The arrangement for the return of the water in a closed pipe, independent, so to speak, of the washing tank, whence there resulted a regular current of water, which kept the pipe sufficiently free. This also effected a considerable saving in the construction, combined with great simplicity.

(6) The arrangement of the hopper G, the stop plug, the emptying apparatus, &c.

When the opening of the gates, the speed of the piston, and the

speed of the pulleys had been regulated according to the coal that had to be washed, and the desired result had been obtained, the working was very simple and gave no trouble.

A man whose sole business it would be to look to the working might manage several washing machines.

The chief work, in attending to the apparatus, consisted in emptying full trucks of coal into the feeding hopper, or removing the trucks full of washed coal and shale, and replacing them by empty ones. The manual labour was thus reduced as much as possible.

The necessary motive power was less than one horse-power per washing bash.

The product may be considerable, and depends on the manner of regulating the apparatus.

By using all the care desirable to obtain properly washed coal, each washing bash may give thirty tons of fine washed coal in ten hours, exclusive of muds and shale, and forty to fifty tons if the coal to be washed does not contain too much dust.

However fine or slimy the coal may be, it can be easily washed in this machine; and the product is still important, although the rate of washing would be less than with coal not so fine.

Lastly, the body of the apparatus being constructed of oak, with iron holdfasts, which is sufficient to ensure long durability, the expenses of first establishment and maintenance are not considerable.

The following is a descriptive list of the various parts of the machine:—

A	Piston tank.
a	Frame of the screen of the washing bash.
B	Piston.
C	Supply hopper.
D	Tank for shale or heavy impurities.
d	Worm for removing the shale, or heavy substances.
d'	Openings for shale.
D''	Compartment for receiving shale &c.
D'	Elevator or chain buckets for delivering the shale &c.
E	Tank with several compartments, for receiving washings.
E'	Elevator or chain buckets for delivering the washed coal or light substances.

F Compartment for the return of water.
F′ Compartment forming a portion for the return of water.
G Hopper for washings.
H Canal round the washing tank.
H′ Canals of the bottom gates.
I Return water pipe.
J Double cam commanding the plunging piston.
K Gate regulating the supply from the hopper C.
L Special grating.
M Gate, or moveable overfall.
N Special grating, like grating L, with bars closer.
O Compartment for lifting the washings into the tank E.
o′ Openings in the two lateral sides of the compartment O.
o″ Partition limiting the compartment O, and protecting the chain buckets.
P Opening made at the bottom of the compartment O.
P′ Another opening of the compartment F.
p Moveable fastening of the compartment F.
Q Opening clack valve for the return of the water.
R, R′ Compartments for the passage of water in the tank E.
S Bottom gate to the tank A.
S′ Bottom gate to the tank E.
T Gate of the compartment F.
U Door of the piston tank.
V, V′, V″, *v*, *v*′ Motive pulleys.
x, *x* Rounds of the bucket chains.
Y Stop bolt of the piston.
Z Cock of the piston rod.

ON

THE MAESTEG TUNNEL.

By Mr. G. F. Adams, M. Inst. C.E.

Although the subject of this Paper has been attended by much that is interesting it would perhaps not have been considered of sufficient importance for a communication to the Institute, from a Civil Engineering point of view only, but coupled with its mining and stratigraphical features it may possess some amount of interest.

The Tunnel is the principal work in connection with the Llynvi and Ogmore Railway Company's Northern Extensions, the Act for which was obtained in 1873; the writer's firm being engineers for the Bill and for the works.

It will be observed from the Plan (Plate 24) that the new lines will form an outlet for new and very important coal fields, and this outlet becomes the more valuable by the amalgamation of the Llynvi with the Great Western system, and by the conversion of the South Wales Railway into narrow gauge.

The extensions commence with Railway No. 6, which forms a junction with the existing Llynvi Valley Railway, near the termination of that railway at Maesteg.

Railway No. 6, immediately after passing through the tunnel, crosses the Avon river by means of a high viaduct, with masonry piers and wrought-iron superstructure. There are four spans of 82 feet 6 inches each, and the main girders are of the "double

Warren" type, 10 feet deep, with 10 feet bays. There are cross girders, 10 feet apart, carrying the wooden decking. The height from the bed of the river to rails is 107 feet. The viaduct is built on a curve of 30 chains radius, the rails being level. It was originally intended to build the viaduct with nine masonry arches of 40 feet span, but it was considered that there would be a difficulty in procuring a sufficient number of masons in so isolated a locality.

Near the village of Cymmer a junction with the South Wales Mineral Railway has been effected, and sidings are being prepared for the interchange of traffic.

Railway No. 7 commences by a junctionwith Railway No. 6 near the northern end of the tunnel, and runs up the Avon Valley to Blaenavon.

The longitudinal section of the tunnel shown on Plate 25, is compiled from the progress section, supplemented by some detailed sections of the seams taken and supplied by Mr. Barrow, and it may throw some little light upon a district which has been the subject of several Papers read before this Institute.

The seam of coal passed through at the north entrance of the tunnel would appear to be identical with the seam proved by the Glyncorrwg Company, near Cymmer village, and supposed to be the "Wernddu Seam," and probably identical with the "Glyncorrwg," or "No. 2 Rhondda" Seam.

The black band passed through near the south end is supposed to be the "Middle Black Band."

The several faults passed through make it difficult to connect the sections. Very much turns upon the position of the large fault proved in the Llynvi Company's workings at Cwmdû and Tygwinbach. One would be led to identify it with the disturbance passed through about the middle of the tunnel, by the very broken nature of the ground on the mountain above it, but the rock on each side of this disturbance would appear to indicate that it is not a very large fault in this immediate locality. It may be that the large fault is the one near the south end, in

which case the black band ought to have come in again. These are merely suggestions, and it is probable that the ground can only be reconciled by those members who know the district best, and have carried on operations in it, putting their working plans and sections together.

The works were let in two contracts. No. 1 contract included Railway No. 6 from the north end of the tunnel to the junction with the South Wales Mineral Railway, and the whole of Railway No. 7. No. 2 contract included the tunnel and Railway No. 6 from its commencement to the south end of the tunnel.

The Diamond Rock Boring Company have been the contractors for the section which includes the tunnel.

The tunnel is 1,594 yards in length, and quite straight, with a rising gradient throughout the whole length towards Maesteg of 1 in 226. This gradient is against the load, but it is slight, and could not be obviated, having regard to the levels which had to be adopted near the southern entrance.

Plate 26 shows the contract sections of the tunnel for different kinds of ground. Section No. 1 is for soft ground, section No. 2 for harder ground, and section No. 3 for hard rock. The contracts were for fixed sums, with the exception of the tunnel lining, but it was considered that a contractor, in tendering, would assume, in order to keep himself on the right side, that the most expensive section of lining would be required throughout. It was therefore decided to get this portion of the work done by schedule of prices, and to change the section as the ground varied, and by so doing a considerable saving has been effected. The following are the contract prices for the different descriptions of work in the tunnel:—

	£	s.	d.
Excavation in tunnel in every variety of strata and material, per lin. yard	18	10	0
Dry masonry in drain throughout bottom of tunnel, per cube yard	0	10	0

	£	s.	d.
Masonry set in mortar in invert, side walls, manholes, arching, or entrance of tunnel, per cube yard	1	5	0
Brickwork set in mortar in invert, side walls, manholes, or arching of tunnel, per cube yard .	1	15	0

N.B.—The net cubic contents of the masonry and brickwork set in mortar, according to drawings, or orders only, to be paid for, and the prices are to include all arches, sidings, caps, coping, imposts, and quoins, and all temporary works and materials.

Owing to the inclination and the frequent bedding of the strata, the ground has nowhere been considered quite secure enough to adopt section No. 3, although a considerable amount of very hard rock has been driven through, but in order to make the underpinning at the south end easier, the contractors have been allowed to build the side walling vertical over considerable lengths, instead of curving it inwards towards formation level as shown on sections, and this gives a greater width at rail level.

The mountain rising very rapidly at each end, no assistance could be obtained from shafts, and the tunnel has been entirely driven from the two ends.

The south end has been driven entirely by hand labour, and the north end chiefly by machine drills.

The north end was commenced in April 1875, and the south end in August 1875, and a junction perfect to lines and levels was effected on 29th May 1877, 957 yards having been driven from the north end, and 637 yards from the south end.

The following is a description of the machinery which was established for driving the drills at the north end:—

The motive power consisted of a pair of portable engines, one 25, and the other 20 horse-power, coupled.

The air compressors were a pair of vertical single-acting cylinders, working at a reduced speed from the engine, 30 inches diameter by 2 feet stroke, and going at 35 revolutions per minute; the valves were of the butterfly pattern, self-acting, and 3 inches in diameter; the inlet valves, 19 in number, being placed in the

piston, and the outlet valves, 12 in number, being placed in a disc under the top cylinder cover.

Main air-pipes 4 inches in diameter, and made of cast iron. Water pipes 2 inches diameter. Water pressure 90 lbs. per square inch; the reservoir being placed sufficiently high to feed the boilers, 10 to 15 lbs. are sufficient for the purpose of the drills.

In the newer compressors used by the contractors, the piston is solid and the small vacant space at the end of each stroke between the piston and the top cylinder cover is taken up by a little water, which rises and falls with the piston. In this case the whole of the valves are in the top cover, the inlet valves on the outside, and the outlet valves inside the main air channel.

The comparatively slow speed of the compressors enables the heat due to compression to be partially got rid of to the atmosphere, resulting in a proportionate economy of power.

The valves are open to inspection, and, with their seats, can be easily and quickly attended to, but they rarely get out of order.

By having the cylinders single acting, their size is of course doubled, but against this is to be set the absence of slide blocks and guides together with bottom cylinder cover and stuffing box; at the same time the inside of the cylinder and piston is always kept cool by the outside air, and is open to inspection.

The compressors have water jackets, the water entering at bottom, and discharging at top.

The Beaumont percussive drill (Plate 27) has, in common with most drills, three motions, viz.

One for giving the blow;
One for turning the drill; and
One for feeding it forward.

The drill is worked by compressed air at a pressure of from 40 lbs. to 50 lbs. on the square inch.

The apparatus consists of a cylinder carrying a piston and piston rod, which is supported on a frame on which it slides longitudinally, being moved by a feed screw, the feed depending on the speed at which the hole is being deepened.

The drill may look cumbersome, but it is no stronger or heavier than is necessary to do the amount of work which is involved in piercing a $2\frac{1}{4}$ inch hole in hard rock, at from 2 to 6 inches per minute; in fact, it is work which needs a small steam hammer to do it.

In designing the drill it has been arranged so that all the working parts, which are those only liable to get out of order, are on the outside of the drill.

It is true that they are exposed to the dirt of a tunnel, but that is more than counterbalanced by the great advantage of the miner being able to see, while the drill is at work, that all parts are in proper order.

Inside there are literally only two moving parts, both of which are solid, namely the piston and valve.

One of the chief specialities of the drill consists in the method of driving the valve, which is set in motion by the air in place of, as is usually the case, by some mechanical connection with the piston, or other moving part of the drill. This enables a dead blow to be given in place of a cushioned one.

Where the valve is driven by the piston, it follows that it must be reversed before the drill strikes the rock, otherwise there would be no motion left to shift the valve to the proper position for the return stroke.

By inspecting the drawings it will be seen that each side of the swell in the centre of the valve forming its piston is alternately put in connection with the pressure at either end of the main cylinder, the exhaust being effected through the open space between the two ends of the divided piston of the drill, which is permanently in connection with the outside air, by a hole drilled through the front part of the piston rod.

Suitable buffers are provided for the valve to strike against, and the same arrangement is carried out with the main piston, so that should the piston accidentally overrun its parts no harm will result.

The twist motion is given by two straight and two inclined grooves cut on the front part of the piston rod. They are made both broad and deep so as to afford a proper rubbing surface. When the drill sticks in the hole, as it often does, an excessive strain is thrown on the twist motions of the drill.

The feathers sliding in the latter are in connection with two ratchet wheels, one taking the straight, and the other the twist grooves.

The object of the two descriptions is to prevent the possibility of the drill ever turning back.

The feed is given by putting the brass nut on the feed screw in connection with a pawl driven by a roller which is pressed against the piston rod, prolonged through the top cylinder cover.

The rod is tapered at the end, and as long as the roller keeps clear of the inclined part no feed is given, but so soon as the deepening of the hole enables the piston to move further towards the front end of its stroke the roller descends the incline, and enables the pawl to take a fresh tooth of the ratchet wheel in connection with it.

The drill can be fed, if required, by hand by simply disconnecting the automatic feed arrangement. But hand feeding is discountenanced where speed is an object; indeed, without an automatic feed in hard and variable rocks bad progress would inevitably be made.

The bed on which the drill slides is of malleable cast iron, allowing a 3 feet length of traverse.

The carriage, or camel, as it is called (Plate 28), consists of two arms supported midway by a vertical iron column carried by a low truck running on four flanged wheels. These arms carry two drills each, the top ones being above the arms supporting them, and the lower ones in boxes which hang from the bottom arms.

The object of this arrangement is to keep all the drills relatively in the same position, so that they can be changed one for the other, and so obtain a full command of holding power.

Holes can be put in in any direction, and, as a matter of fact, hand holes are never needed.

It will be seen that the central column is capable of turning; and the arms, again, can turn on it.

The clamps carried by the arms can slide horizontally, and turn upon them, while the drills have similar motions.

When the drilling is completed, the arms carrying the drills are turned longitudinally with the tunnel, and the camel is run back into a siding to allow of the muck wagons being readily passed by it.

For rapid and economical tunnel driving by machinery, it is absolutely essential that a powerful drill should be used, and that the liability to breakage should be reduced to a minimum.

A set of four of the Beaumont drills are capable of putting in 16 to 20 holes 3 feet 6 inches deep in hard rock in three hours, and of keeping this average up.

The advanced heading in which the drills have worked has been driven about formation level in the centre of the tunnel, and 8 feet wide by 8 feet high.

As a general rule 16 to 18 holes are bored into the face, their average length being $3\frac{1}{2}$ feet to 4 feet in hard rock, and 5 feet to $5\frac{1}{2}$ feet in soft ground.

These holes commence with $2\frac{5}{8}$ inches drills, and finish at $1\frac{1}{2}$ inches, four to five different drills being ordinarily used in the length in rock, and three inches softer ground. Considerable judgment is required to drill the holes at the angle most effective for the particular ground; as a general rule, the top holes rake upwards, and lower holes downwards.

The boring of all the holes takes about four hours as a general rule.

The four centre holes, converging inwards, are first blasted, then the top and side holes, and after the rubbish has been cleared away in front of them the bottom holes are blasted.

The blasting and clearing of the rubbish takes about four hours.

About 20 lbs. of dynamite are used for the above number of holes in rock, and from 10 to 12 lbs. in softer ground.

At the above rate a yard is advanced each eight hours, making 3 yards a day, or 18 yards a week.

The average for seven consecutive weeks was 18½ yards per week.

The full complement of men for driving the heading by machinery during one complete operation is, viz. :—

1 Foreman
1 Timekeeper
1 Engine driver
1 Fireman
1 Fitter (outside)
1 Fitter's labourer ditto
2 Blacksmiths
2 Strikers
2 Labourers, carrying tools and attending to air pipes
*5 Men working machines at face
5 Men blasting and clearing rubbish away
1 Horse driver
1 Miner road-laying after machine, and doing any timbering that may be necessary
1 Man attending to explosives, candles, &c.
1 Boy messenger

26 Total

The progress of the work has afforded opportunities for comparing results by machine drills with hand labour, and at one time in particular two headings were driven simultaneously in the same hard rock for some distance at the north end, the one by machinery, and the other by hand labour. Over several

* This number is sometimes increased to six.

consecutive weeks the hand labour averaged $3\frac{1}{3}$ yards per week, and the machine drilling $18\frac{1}{2}$ yards per week, or five-and-a-half times the speed of hand labour.

Without going into the actual cost—a matter belonging exclusively to the contractors—the writer may be permitted to state, for the information of the Institute, that the actual working cost per yard in hard rock is about the same with machine drills as with hand labour, without taking into account the interest on capital and the depreciation of machinery; in addition to the increased speed, more ground is taken out by the machine drills per yard forward, as headings by hand labour are ordinarily only driven 5 feet by 6 feet; and if the hand heading in hard rock were taken out the same size as the machine headings, the progress in the latter case, instead of being $5\frac{1}{2}$ times greater, would be about 8 times greater. In softer ground the advantage of machine drilling of course decreases; the speed of machine drilling as compared with hand labour would be about as 3 to 1.

The above highly favourable results were not obtained all at once, and are due to the skill and perseverance with which the patentee, Colonel Beaumont, and his agents have displayed in perfecting the mechanical details, and the practical working out of the drill machinery; and before arriving at this successful issue a large expenditure of money had necessarily to be made by the contracting company, in experiments and improvements in the drill, and the appliances attending it from time to time.

For a short time at the early stage of the contract the diamond drill was used, but the cost of the diamonds was found to be too great for this description of work, although the machine remains unequalled for the deep bore holes required in prospecting.

The plant required for driving an advance heading similar to the one at the north end of the Maesteg Tunnel may be assumed to cost about £2,000.

Where only moderate progress is required, and it is wished to incur a smaller outlay, as is frequently the case in mining, a smaller

pattern of drill is sold by the Diamond Rock Boring Company with a $3\frac{1}{4}$-inch cylinder, and 2 feet length of travel; this drill has no automatic feed, and can be worked on an altogether lighter frame than the camel used for large tunneling operations.

Where the nature of the ground admits of intermediate shafts, and the simultaneous advancement of the different faces thereby gained enables a tunnel to be driven on rapidly, the full-sized tunnel can be more economically driven by keeping the advanced heading on the top, but this system of working affords only one face for the opening out to full size; and where the ground is weak and the face has to be squared down for every length of lining that is put in, the mining during that operation has to come to a full stop. It is therefore necessary, unless time be of no importance, to keep the advanced heading at the bottom, so as to secure several different points for breaking up to full size of tunnel; and it may be stated here that the operation of breaking up was found to be easier going south with the strata rising than in the opposite direction.

At the south end the advanced heading, together with the opening out to full width at the several points, was driven for the most part only to water level. The contractors' agent who started the work, considering that it would be more economical to go on in this way until the junction afforded free drainage to the north end, and afterwards to underpin the side walls, and bottom up, rather than take the full depth of tunnel down with the gradient, by means of pumps, but time so pressed that pumps had to be applied to assist in these operations before the junction was effected, and inclined roads were driven from the water line to formation level, and from this point the tunnel was excavated to full section forwards for some considerable distance, to the junction with the north end, and the bottoming up and underpinning of masonry, which was done in short lengths, was worked backwards on the rising gradient to the south end. The ground in some places was rather heavy, requiring 14 bars of 15 inches diameter, which is rather heavy timbering for a single tunnel, and

in such cases lengths of only 12 feet lining could be put in, the general lengths being 18 feet, four or five centres or ribs being used.

Top headings had, of course, to be driven sufficiently in advance to draw the bars. In some instances where the ground was good several lengths were opened out and turned at a time.

The engineers, having regard to the difference in cost and to the greater durability of stone, elected to adopt masonry rather than brick lining, but the contractors finding the stone, although abundant, costly to dress, and that it took four to five days to turn a length in masonry, whilst it could be done in 24 hours in bricks —an important consideration when the advance heading was at the top, and the ground loose—and having a considerable amount of trouble with the Union masons, applied for permission to adopt brickwork at the same price as masonry. This was granted, and the Pencoed brick adopted.

In turning a length of 18 feet in brickwork, three bricklayers would be engaged, changing from side to side, but in masonry there would be three masons on each side. In brick lining the time in turning a length is taken up as follows :—Side walls, 10 hours; setting centres, 6 hours; arching, 8 hours ; total, 24 hours. In masonry lining two days are taken in building the side walls, and two days in setting the centres and arching.

On the 21st April, 1876, a very lamentable accident occurred at the north end, in which 13 lives were lost by an explosion of dynamite, in a manhole 176 yards from the tunnel mouth, and where the charges were being prepared. Most of the men were killed in a break-up about 37 yards inside the manhole. The concussion was hardly felt at all in the face of the advanced heading, about 202 yards distant ; and some men in a break-up 133 yards from the manhole were also uninjured, but the blast came out towards the entrance with terrific force. The men who were killed were not mutilated, but it is difficult to say whether death was caused by the concussion, or by the very overpowering fumes of exploded dynamite. Probably both causes operated.

The tunnel, which is nearly completed, will cost the Railway Company about £29. 15*s.* per yard forward, or about £47,422 for the whole length.

The drills have only been used in the advanced heading, but the writer ventures to think that the time is not far distant when the whole of mining work in driving tunnels through hard ground will be accomplished by machine drilling, especially in cases where the tunnel is taken out full size in one face, although improvements are probably more to be looked for at present in the appliances attending the drills, and in the detailed management of the work, rather than in the drills themselves.

The writer is informed that the same percussive drills are driving a heading in Cornwall 7 feet by 8 feet in the hardest Tin Capel at the rate of 10 yards per week; the progress with hand labour having been only 1 yard per week, the advantages here being ten times in favour of machine drilling, whilst much more ground is taken out—a very important consideration when the heading is driven in the mineral lode.

The Diamond Boring Company have just completed with these drills the junction lengths of bottom heading of the Queensbury Tunnel for the Great Northern Railway Company, near Bradford, and for which Mr. Fraser is engineer; the ground was rocky shale and good for progress; an actual rate of 28 yards per week was reached, and during the last month, previous to the heading being holed, a total of 105$\frac{1}{3}$ yards was driven. A return of the work done by the drills at Queensbury Tunnel has been supplied to the writer, who, thinking it would be of interest to the Institute, has appended it to this Paper.

Speed with the advanced heading means actual economy of construction, because an increase in the cost of driving the heading must be set against the cost of the shafts, with all their pumps and gear for working them, which are unnecessary where the bottom heading can be driven sufficiently rapidly.

Take the case of a long tunnel like that at Queensbury, where seven shafts were commenced, five having been put down,

and two abandoned owing to the great difficulty of dealing with the quantity of water which was met with. In such a case as this no cost which the use of machinery could put on the advanced heading would nearly come up to the saving effected by the shafts and the pumping being dispensed with. The writer is informed that this tunnel is 2,500 yards long, that the aggregate depth of shafting amounted to 546 yards, and that the quantity of water raised was about 1,000 gallons per minute.

The successful results achieved by machine drilling are likely to give a great impetus to tunnel driving in the future, affording new outlets for our coal and manufactured products ; for without machine drilling, or some process of excavating by machinery, the Severn Tunnel, an undertaking of vast importance to South Wales, would probably never have been started, and the Channel Tunnel between France and England, although in softer ground, never seriously contemplated.

APPENDIX TO MR. G. F. ADAMS'S PAPER "ON THE MAESTEG TUNNEL."

TABLE OF RESULTS OF MACHINE BORING AT THE GREAT NORTHERN (QUEENSBURY TUNNEL), HALIFAX AND OVENDEN RAILWAY, with four Machines (Beaumont's Patent). Commenced July 12th, 1877. Finished 2nd Oct., 1877.

THE RISE HEADING.

Analysis	Results per Month				Results per Yard				Remarks
	July	Aug.	Sept.	Oct.	July	Aug.	Sept.	Oct.	
Month's progress	Yards 48½	Yards 82	Yards 105⅓	Yards 3					In Millstone, Grit and hard Shale
Progress per working day	Yds. ft. in. 2 1 8	Yds. ft. in. 3 1 4	Yds. ft. in. 3 2 3	Yds. ft. in. 3 0 0					Slight delay caused by breaking down of pumps and blowing engine.
Number of boring shifts	36	48	75	2	·74	·58	·71	·66	
Ditto clearing shifts	36	50	75	3	·74	·61	·71	1·00	
Total time occupied boring	Hrs. min. 145 10	Hrs. min. 160 15	Hrs. min. 215 50	Hrs. min. 8 0	3·00	1·57	2·3	2·40	
Ditto clearing & blasting	242 25	299 45	423 35	18 15	5·00	3·39	4·1	6·5	
Average duration of boring shifts	4 2	3 20	2 53	4 0	3·1	1·58	2·2	2·40	
„ „ clearing shifts	6 43	6 0	5 39	6 5	5·2	3·40	3·59	6·5	
„ „ boring & clearing	5 22	4 40	4 16	5 2	4·1	2·49	3·0	4·22	
Total number of holes bored	576	780	1,356	44					
„ length of holes bored—in feet	2,880	3,900	6,780	220	59·4	47·55	64·4	73·4	
Length of holes per shift	80	81·25	90·4	110	60	48·75	63·8	88·0	
Average depth of holes—in feet	5	5	5	5	3·75	3·0	3·5	4·0	
Advance per shift	Yds. ft. in. 1 1 0	Yds. ft. in. 1 2 0	Yds. ft. in. 1 1 3	Yds. ft. in. 1 0 9					

TABLE OF RESULTS OF MACHINE BORING AT THE GREAT NORTHERN (QUEENSBURY TUNNEL), HALIFAX AND OVENDEN RAILWAY, with four Machines (Beaumont's Patent). Commenced July 19, 1877.

THE DIP HEADING.

Analysis	Results per month		Results per yard		Remarks
	July	August	July	August	
Monthly progress	Yds. 29	Yds. $62\frac{21}{6}$			
Progress per working day	Yds. ft. in. 2 2 8	Yds. ft. in. 2 1 6			Rise heading began, 12th July.
Number of boring shifts	20	42	·69	·675	Dip „ „ 19th „
„ clearing shifts	21	43	·72	·692	During July and August the same machine was used for the two headings, being moved backwards and forwards. After the dip heading was holed, the machine was exclusively employed at the rise.
	Hrs. min.	Hrs. min.			
Total time occupied boring	71 45	147 0	2·28	2·22	
„ clearing away débris	150 30	289 15	5·11	4·40	
Average duration of boring shifts	3 35	3 30	2·29	2·23	
„ „ clearing „	7 10	6 44	5·10	4·40	
„ „ boring and clearing	5 22	5 7	3·49	3·31	
Total number of holes bored	320	744			
„ length of holes bored, in feet	1,600	3,720 0	55·2	59·8	
Length of holes per shift	80	88 6	56·5	60·5	
Average depth of holes, in feet	5	5 0	3·5	3·4	
Advance per shift	Yds. ft. in. 1 1 3	Yds. ft. in. 1 1 $4\frac{1}{2}$			

PROCEEDINGS.

17th January 1878.

The Twentieth Annual General Meeting of the Institute was held at the Castle Hotel, Merthyr Tydfil, on Thursday, the 17th of January 1878.

Mr. JAMES MURPHY, Assoc. Inst. C.E., Vice-President, in the chair.

The Minutes of the last General Meeting were read and confirmed.

ELECTION OF NEW MEMBERS.

The Chairman announced that the Ballot Lists had been opened, and declared the following gentlemen to have been duly elected as Members of the Institute, viz.:—

As Member.

Mr. Richard Donald Bain, H.M. Inspector of Mines, Newport, Monmouthshire.

As Graduate.

Mr Azariah Thomas, Assistant Mining Engineer, Porth, Pontypridd.

ANNUAL STATEMENT OF ACCOUNTS AND REPORT.

The CHAIRMAN laid before the Members the following Financial Statement and Report of the position of the Institute for the Session 1876-77, ending October 29, 1878:—

DR. FINANCIAL STATEMENT, SESSION 1876-77. CR.

RECEIPTS UP TO 29TH OCTOBER 1877.

	£	s.	d.	£	s.	d.
To Balance, 29th October 1876				368	0	6
,, Cash received from Members	144	18	0			
,, Dividends, Midland Railway	32	17	7			
,, Sale of Books	7	16	0			
,, Interest from Bank	6	9	9			
,, Cash from Members in further repayment of Expenses, *re* Lancashire Excursion	12	17	6			
				204	18	10
Total				£572	19	4

Audited and found correct,
this 17th day of January 1878.
G. F. ADAMS, MARK LEE } *Auditors.*

EXPENDITURE UP TO 29TH OCTOBER 1877.

	£	s.	d.	£	s.	d.
By Printing and Stationery	44	18	1			
,, Engraving	63	14	6			
,, Reporting	18	18	0			
,, Secretary	80	0	0			
,, Sundries	58	2	4			
,, Midland Railway Stock	60	0	0			
				325	12	11
,, Balance				247	6	5
Total				£572	19	4

GENERAL STATEMENT.

ASSETS UP TO 29TH OCTOBER 1877.

	£	s.	d.	£	s.	d.
To Balance brought down				247	6	5
,, Midland Consolidated Stock	649	13	2			
,, ,, 5 per cent. Perpetual Preference Stock	60	0	0			
,, ,, 4½ per cent. Preference Stock	50	0	0			
,, ,, 5 £17 4 per cent. Preference Shares, £9 paid	45	0	0			
				804	13	2
,, Books, due for				32	5	0
,, Subscriptions due to 29th October 1877	499	16	0			
Less irrecoverable	44	2	0			
				455	14	0
,, Due on advances, *re* Lancashire Excursion—						
Last account £20 1 5						
Less paid 12 17 6						
	7	3	11	7	3	11
Total				£1,547	2	6

LIABILITIES TO 29TH OCTOBER 1877.

	£	s.	d.	£	s.	d.
By Printing and Stationery	40	0	0			
,, Engraving	17	17	0			
,, Reporting	5	5	0			
,, Sundries	10	0	0			
				73	2	0
,, Balance				1,474	0	6
Total				£1,547	2	6

REPORT.—Session 1876-77.

The accompanying Financial Statement shows the general position of the Funds of the Institute at the close of the last Session, ending 29th October 1877, to have been as follows:— The sum of £804. 13*s.* 2*d.* *stood invested* in *Midland Railway Stock and Shares.* The *Dividends* on Railway Stock amounted to £32. 17*s.* 7*d.*, or about 4¼ per cent. per annum. The amount received and due for *Books sold* was £40. 1*s.* The *Interest* received from the Bank amounted to £6. 9*s.* 9*d.* The amount received and due for *Members' Subscriptions* was £600. 12*s.*, together with an amount of £20. 1*s.* 5*d.* received and due on account of the *Lancashire Excursion.* And the cash balance brought forward from last Session amounted to £368. 0*s.* 6*d.* These sums together give a total credit of £1,872. 15*s.* 5*d.*

On the other side, *General Expenses* were paid to the amount of £265. 12*s.* 11*d.*, the *Liabilities* thereon amounted to £73. 2*s.*, and the sum of £60 was *invested in Midland Railway Stock*, leaving a *Balance* in favour of the Institute of £1,474. 0*s.* 6*d.*, of which sum £247. 6*s.* 5*d.* was represented by *Cash* at the Bankers.

During the Session the Institute has lost one Member, in the demise of the late Mr. Jabez Brown, of Mountain Ash.

Five Members have resigned, and six have had their names taken off the Roll Book, in accordance with the 44th Regulation.

During the Session twelve names have been added to the list of Members of the Institute, which now comprises:—

185	Members.
4	Associates.
18	Graduates.
Total 207	

ELECTION OF OFFICE-BEARERS FOR THE SESSION 1877–78.

The CHAIRMAN declared the following Office-Bearers, nominated at the last General Meeting to succeed those gentlemen retiring by rotation, to be duly elected, viz.:—

President.

Mr. Richard Laybourne, M. Inst. C.E.

Vice-Presidents.

Mr. David Thomas.
„ Jas. M'Murtrie, F.G.S.

Members of Council.

Mr. J. R. Waddle.
„ George Birbeck.
„ Marcus Moxham.
„ G. F. Adams, F.G.S., M. Inst. C.E.
„ Matthew Bates.
„ E. P. Martin.

Secretary.

Mr. Hort. Huxham, F.G.S., M. Inst. C.E.

The CHAIRMAN said they had to regret the absence of the retiring President, who, as he was going abroad, had very important matters to attend to before leaving England, and had found it impossible to be present that day; he was sure, however, that the Institute would cordially award him a vote of thanks for the manner in which he had discharged the Presidential duties during his term of office.

Mr. R. BEDLINGTON said he had much pleasure in proposing that a cordial vote of thanks be given to the retiring President,

Mr. James Brogden, for the able manner in which he had discharged the duties of President during the last two years.—This, having been duly seconded, was carried unanimously.

The CHAIRMAN reminded the Members that the Institute had now been founded for twenty years, and said that the Council had that morning been considering the desirability of establishing their head quarters at Cardiff, as being the most central and convenient position. It was hoped that this important step would conduce to the advancement and substantial progress of the Institute, and the Council purposed submitting a resolution to that effect for the approval of the Members at the next General Meeting.

The discussion of Papers read at previous meetings was then proceeded with.

No remarks being offered in respect to the following Papers, the discussion was in each case taken as closed, viz :—

On "Personal Experiences in Tubbing Shafts, and other Colliery Work," by Mr. George Wilkinson.

On "The Miner's Life Preserver," by Mr. A. Upward.

ADJOURNED DISCUSSION ON "SAFETY LAMPS."

The CHAIRMAN said that Mr. W. E. Teale's Paper on "Safety Lamps" came next on the list for discussion. He looked upon this as an exceedingly important subject connected with the mining interests, and although he had had little or no experience with safety lamps, yet he had noticed from time to time the great ingenuity that had been displayed, in the various forms of lamps now in use, for providing an efficient light and safety from the risk of explosions. He looked forward, however, to the not far distant day when the electric light would come into universal use for mining purposes.

Mr. T. G. Davies said that he had tried the Davy Protector Lamp, and although under certain conditions it gave an excellent light, yet he found there were some objections to its use. He noticed that the author had stated in his Paper that it had been pointed out that, although the light could not be exposed, the collier had the power of taking off the lamp bottom and, by means of a match, relighting the lamp without detection, which no doubt was correct; and he observed that it was proposed to obviate the objection by attaching a lead pin, which, passing through the bolt, prevented the lamp being opened without first cutting off the plug. Now, whilst the lamp acted in its ordinary way the height of the flame might be regulated by slightly unscrewing the bottom part of the lamp, so as to depress or elevate the flame within the extinguishing tube or regulator K (*see* Plate XIX.) as occasion might require. If, however, the bottom part of the lamp be fixed or locked that could not be done, and there would then be no means of regulating the height of the flame. His experience with the Protector Lamp, and with others burning a similar class of oils, was that the flame became lengthened, assumed a reddish colour, and lost its brilliancy in passing from a cool atmosphere into that of a higher temperature, as in the return airways and other parts of the mine, and that when the lamp was secured by a lock so that the bottom part could not be turned, there was no means of regulating the flame. He found it gave a very good light, and was considerably more delicate in showing indications of the presence of gas by the "cap" or "top" on the flame than ordinary lamps.

Mr. Walters said that he had tried a dozen of the Protector Lamps, but had been obliged to give up their use because of the trouble and annoyance from the lamps going out so much more easily than the ordinary Davy Lamp, and on dusty roads he found them more difficult to keep alight. He did not consider that they could be used as safety lamps wherever it was requisite to use "locked safety lamps." There was no doubt some economy in the use of the oil, and the lamps gave a good light.

Mr. R. BEDLINGTON said that there was a very important objection to the use of the lamp, inasmuch as it could not be used as a "locked safety lamp," for the collier could unscrew the top, and afterwards with a match relight the lamp. He considered that was a serious objection, notwithstanding that the lamp could not be opened without extinguishing it.

Mr. GEORGE WILKINSON said that he had tried some of the Protector Lamps, having been under the impression that there was a considerable saving in the cost of the oil. The colliers, however, did not like them, as they complained that the light went out so easily, especially from any jerks to the lamp. He used them himself for several days, but found them very delicate and difficult to manage. He was able to carry them in any of the intake air currents, but when he attempted to go into the return air courses, where the temperature was 60 to 64 degrees, he could not keep them alight. He found also that there was considerable loss of the colzaline by evaporation; so that but little gain arose from that source. Seeing, therefore, there was so much difficulty and uncertainty in using the lamp, he did not proceed further. The lamp gave a good, steady light, with a clear flame, but, in his opinion, was too delicate for general use.

The discussion then closed.

ADJOURNED DISCUSSION ON "AN IMPROVED FIRE-BAR."

The CHAIRMAN said that the discussion on this Paper had been postponed from the last meeting to enable Mr. Moxham to obtain the result of some experiments as to the saving of fuel to be effected by the use of this bar; but the Secretary informed him that Mr. Moxham was unable to be present.

Mr. MENELAUS said he had no desire to discuss the question until they had an opportunity of having further information from Mr. Moxham. He thought that the Paper would be more valuable if Mr. Moxham had described the kind of fire-bar he had

used before, and which this hollow bar supplanted. It was also desirable to know how much of the saving was due to the application of the blast, because the coal, for instance, might be in a condition not to burn readily, and the application of blast might thus be an important element in the question. Before coming to any conclusion as to the value of the bar, they ought also to know the condition of the furnace, whether there was sufficient draught or not, the size and length of the bars used, the character and quantity of fuel consumed, and other general or special features. The idea of distributing the air had been a favourite scheme for the last fifty years, and hundreds of plans and patents had been brought out for splitting up the air as circumstances required over the area of the grate. The saving claimed for the bar under discussion was 15 per cent., but he would have considered $2\frac{1}{2}$ per cent. to be an important saving; and it was therefore very desirable that the discussion be put off until the experiments suggested have been made, and full information given on all points. It was no use to state what was being done under one set of circumstances unless it was known what had been done before. When it was said that 15 per cent. of fuel was saved by a new fire-bar, it seemed to him that there must have been a bad arrangement before.

The CHAIRMAN said that he had suggested at the last meeting that some particulars of the saving claimed to be effected between the old fire-bar and the new should be given. The new bar had been described without taking into consideration what had been done with the old one. Upon putting in the new bar, no doubt considerable attention had been paid to detail, which, if applied to the old bar, might also have resulted in considerable saving. There had been so many experiments and so many improvements in fire-bars, that one would think there must be little more to attempt. He observed in the *Engineer* that some Mr. Martin had adapted an improvement for sea-going boilers, of which he gave particulars, and claimed a saving of from 10 per cent. to 15 per cent. in the fuel. Such things were steps in the right

direction, but whether they would succeed or not time alone would determine.

The discussion was then adjourned to next meeting.

DISCUSSION ON AN "IMPROVED COAL-WASHING MACHINE."

The CHAIRMAN said that this was a short descriptive Paper by M. Rivière, presented through the President, of an Improved Coal-washing Machine constructed in France. Neither the President nor M. Rivière had been able to attend the meeting, but he should be glad to hear any remarks upon the subject.

Mr. HORT. HUXHAM said that the Paper was a description of an "Improved Coal-washing Machine," constructed by M. Rivière, a French engineer. The President (through whom the Paper had been presented) had informed him that the machine had been working very successfully, but further than that he had been unable to obtain any particulars or results. The Paper itself gave a full description of the machine, and stated the principal advantages that were claimed for it. He could not help regretting, however, the entire absence of any particulars of the work done by the machine, or any data by which the results might be compared with other washing machines. In general features—of using the same water over and over again, in the removal of the shale and of the coal—it very much resembled the type of washing machine lately introduced so successfully by Mr. Sheppard, though differing in many details of arrangement and combination of working parts. It would appear, however, from the plans, that this machine gave a longer period for the settling of the small coal after leaving the washing bash, and in quieter water, than in the form of machine used by Mr. Sheppard, and there was also some greater facility for draining off the water from the discharged washed coal. The arrangement for a continuous feed or supply of coal was also well maintained. He

TINE.

PLAN

Accompanying M. A. Rivière's Paper

on the

IMPROVED WASHING MACHINE.

FIG. 1. LONGITUDINAL SECTION.

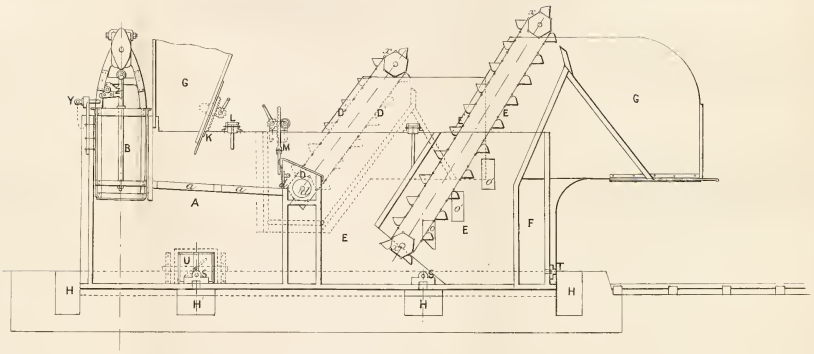


FIG. 2. SIDE ELEVATION.

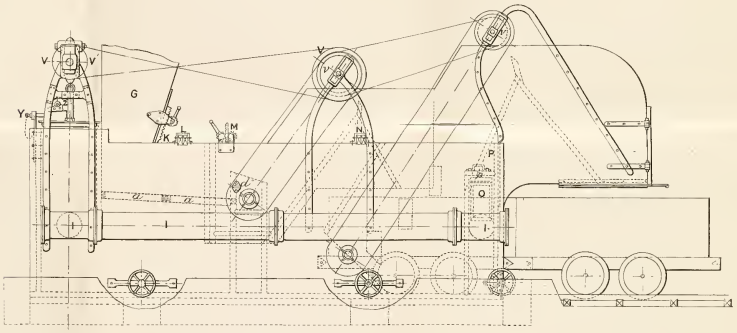
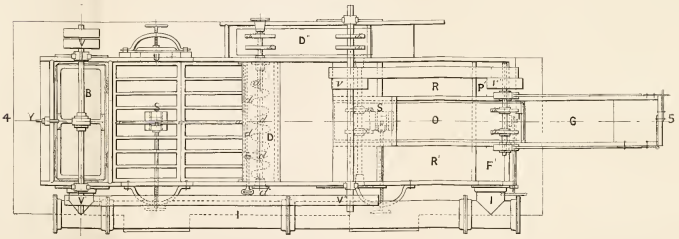


FIG. 3. PLAN.



REFERENCES.

- A *Piston tank*
- a *Frame of the Screen of the Washing tank*
- B *Piston*
- C *Supply hopper*
- D *Tank for shale or heavy impurities*
- d *Warm for removing the Shale or heavy substances*
- d' *Openings for shale*
- D'' *Compartment for receiving Shale &c*
- D' *Elevator or Chain buckets for delivering the Shale &c*
- E *Tank with several compartments for receiving washings*
- E' *Elevator or Chain buckets for delivering the Washed Coal or light substances*
- F *Compartment for the return of the Water*
- F' *Compartment forming a portion for the return of the Water*
- G *Hopper for washings*
- H *Canal round the washing tank*
- H' *Canals of the bottom gates*
- I *Return water pipe*
- J *Double Cam commanding the plunging piston*
- K *Gate regulating the supply from the hopper C*
- L *Special grating*
- M *Gate or moveable overfall*
- N *Special grating like grating L with bars closer*
- O *Compartment for lifting the washings into the tank E*
- o' *Openings in the two lateral sides of the compartment O*
- o'' *Partition limiting the compartment O and guiding the chain buckets*
- P *Opening made at the bottom of the compartment O*
- P' *Another opening of the compartment F*
- p *Moveable Fastening of the compartment F*
- Q *Opening clack valve for the return of the water*
- R.R' *Compartments for the passage of water in the tank E*
- S *Bottom gate to the tank A*
- S *Bottom gate to the tank E*
- T *Gate of the compartment F*
- U *Door of the piston tank*
- V.V'V'' *Motion pulleys*
- x.x *Bounds of the bucket chains*
- Y *Stop bolt of the piston*
- Z *Cock of the piston rod*

was disposed to think the machine was one well adapted for its intended purpose.

Mr. MENELAUS said that coal-washing machines of the type under discussion had been in use on the Continent for many years, and he thought Mr. Sheppard was entitled to the credit of having introduced them successfully into this district. Very possibly the machine described by M. Rivière did its work successfully, but without particulars or results there was no means of arriving at a proper judgment.

Mr. J. T. EDMONDS remarked that when Mr. Sheppard brought the coal-washing machine which he was making before the notice of the Institute, he had stated that it was not his invention, and that he simply introduced it as a successful coal washer.

The discussion on this Paper was then closed.

The discussion of the following Papers was postponed to the next meeting, viz. Mr. Galloway's Paper on "The Firedamp Cap," and Mr. George Birbeck's Paper on "The Bryncethin and Ogmore Valley Mineral Districts."

DISCUSSION ON "THE MAESTEG TUNNEL."

The CHAIRMAN said that the next subject for discussion was Mr. G. F. Adams' Paper on "The Maesteg Tunnel." It was some years since he had been connected with tunnelling, but he thought much credit was due to the engineering skill displayed in so successfully carrying out the tunnel and overcoming the difficulties of passing through a good deal of bad ground. In tunnelling operations he thought it was very important that the best materials should be used in the construction of the lining, and that it should be set in the best hydraulic mortar. They had lately had an instance of the failure of inferior work in a tunnel

in the neighbourhood, which will involve a very large cost in repairs and reconstruction.

Mr. BEDLINGTON said that Mr. Adams stated that 16 or 20 holes, 3 feet deep, were bored into hard rock in three hours, and that the machine was capable of keeping up that average. Further, that 16 or 18 holes, $3\frac{1}{2}$ feet to 4 feet deep, were bored into hard rock, or 5 feet to $5\frac{1}{2}$ feet deep in soft ground. He would be glad to know what was the rate obtained in boring from the commencement to the termination, and what was the average rate at which the tunnel was driven per day or per month.

Mr. COLQUHOUN said that during the progress of some boring operations for the "Black Band" in the Tygwyn Valley he had always suspected there was a large fault passing up the valley, and would wish to ask whether any fault had been discovered near the Maesteg Tunnel answering to that going up the Tygwyn-bach Valley.

Mr. A. J. STEVENS inquired whether any drill besides that patented by Colonel Beaumont was used in driving the tunnel.

Mr. G. F. ADAMS said that, from an engineering point of view, there was really very little to add to his Paper. In the driving of the tunnel the ground was not unusually bad; and, except that a large amount of hard Pennant rock had been pierced, there was no special difficulty. The main features of the stratification passed through were described in the Paper; and it had been hoped that the perforation of the tunnel would have thrown some light upon the mineral characteristics of the district; but the tunnelling operations did not discover much that was new. Two or three faults were passed through, and he thought the fault near the centre was the same as that proved at or near Tygwyn-bach on the Llynfi Company's property; but that fault, which was supposed to be of large dimensions, became very much less where the tunnel passed through it. The principal feature in the work was the very successful driving of the bottom heading in the Pennant rock by the "Beaumont drill." The

Diamond drill was used at the beginning, and there was no doubt that, for the mechanical operation of drilling alone, there was no drill equal to it; but, owing to the great cost of the diamonds and to their getting lost—for if one broke off it had a tendency to loosen all the rest—it was discontinued; for boring, however, in long lengths, or to great depths, there was nothing equal to it. The only percussion drill employed was that patented by Col. Beaumont, and used by the contractors, the Diamond Rock-boring Company. The drill strikes a dead blow, and not a cushioned blow as is necessarily the case with almost every other description of percussive drill; this result is obtained by driving the valve by the air itself, instead of by tappets, which are very liable to wear, and often break, causing great damage to the machinery. There was considerable difficulty in starting, as the men had to be trained to the work and to the use of the machinery, and it was not until the contract was well advanced that the favourable results recorded in the Paper were achieved. As regarded the lining, the tunnel was started with stone, but owing to the difficulty of procuring stonemasons and the loss of time incurred in building the lining of stone, bricks were resorted to, the contractors undertaking to put the brickwork lining in at the same price as stone, though in the schedule it was a much higher price. The best Aberthaw or hydraulic lime was used for the mortar.

Mr. Menelaus asked whether Mr. Adams considered it proved that, in passing through such ground as had been described, the Diamond drill, from its expense, was a failure as compared with the percussion drill.

Mr. G. F. Adams thought that might be taken for granted. On the Continent they were perfecting a rotary drill that promised to be a success, its chief feature being to use steel, hardened to a degree that would enable it to do the work of the diamonds.

The Chairman said that steel had been exhibited to him, made by Cammel, that would cut through anything else, and he

had found that steel tires gave way under that steel; it was amazingly hard.

Mr. MENELAUS thought that the conditions of drilling rock were not the same.

Mr. G. F. ADAMS said he did not advocate any particular drill, but from the observations he had made he was quite satisfied that there is no example on record so successful as this, and which was entirely due to the mechanical details of the drill.

The CHAIRMAN begged to move a vote of thanks to Mr. Adams for his able Paper, which was not only valuable for its description of the work, but specially valuable for its practical information on the expense of driving through Pennant rock.

The discussion then closed, and a unanimous vote of thanks was accorded to Mr. G. F. Adams for his able Paper.

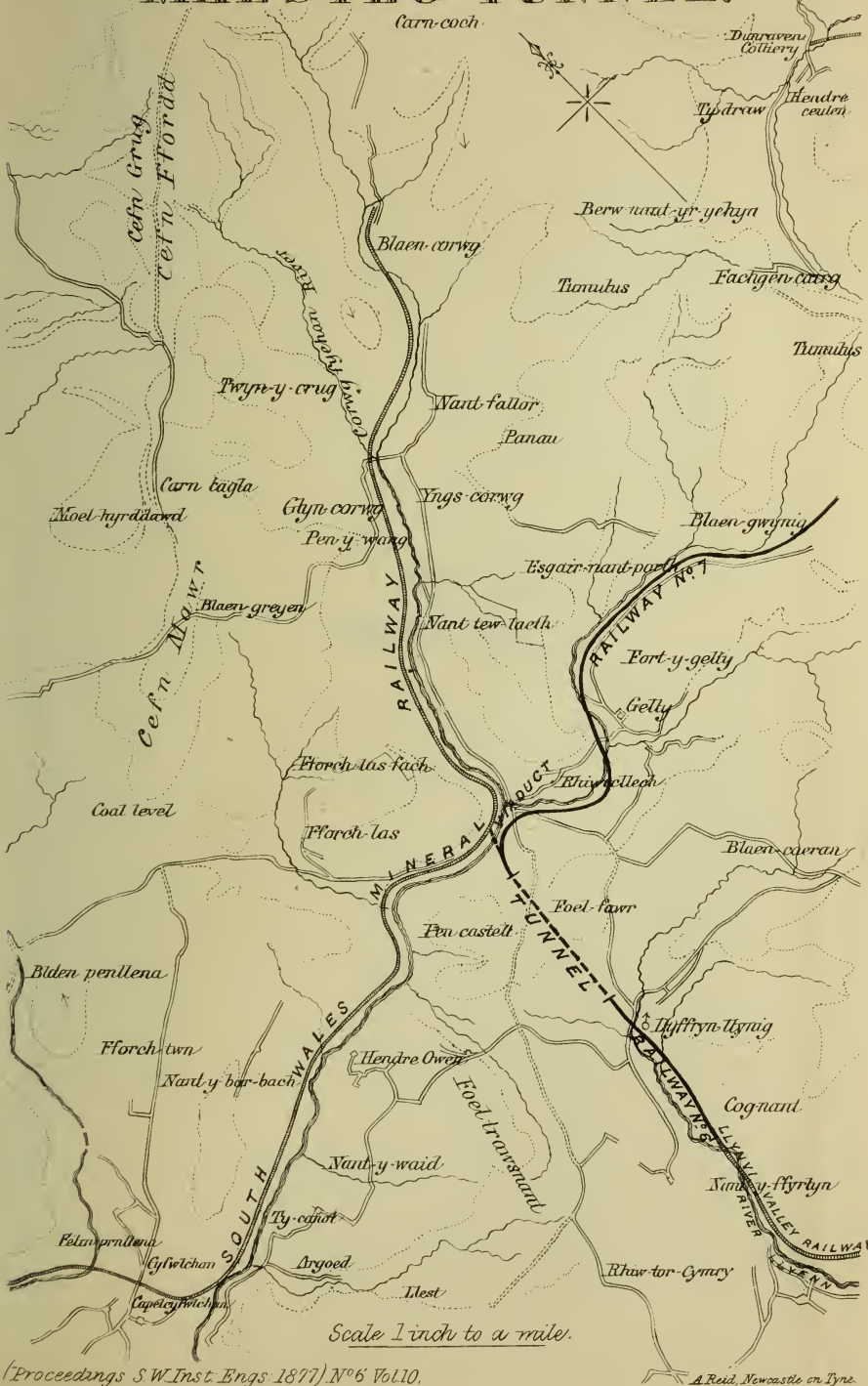
The SECRETARY then read the following Paper by Mr. Edward Plummer, on "The Mineral District from the Avon Valley to the Neath Trough."

PLAN

Accompanying Mr. G.F. Adam's paper

on the

MAESTEG TUNNEL.



(Proceedings S.W. Inst. Engs. 1877) No 6 Vol 10.

A. Reid, Newcastle on Tyne.

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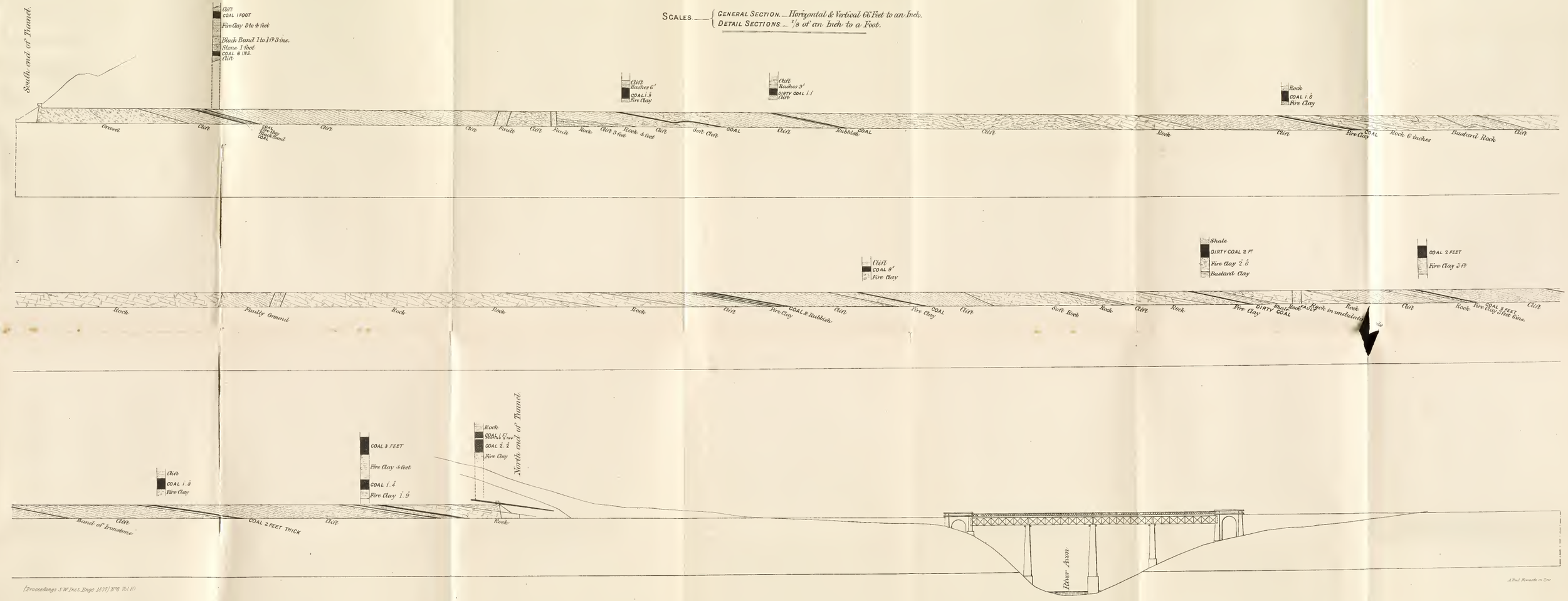
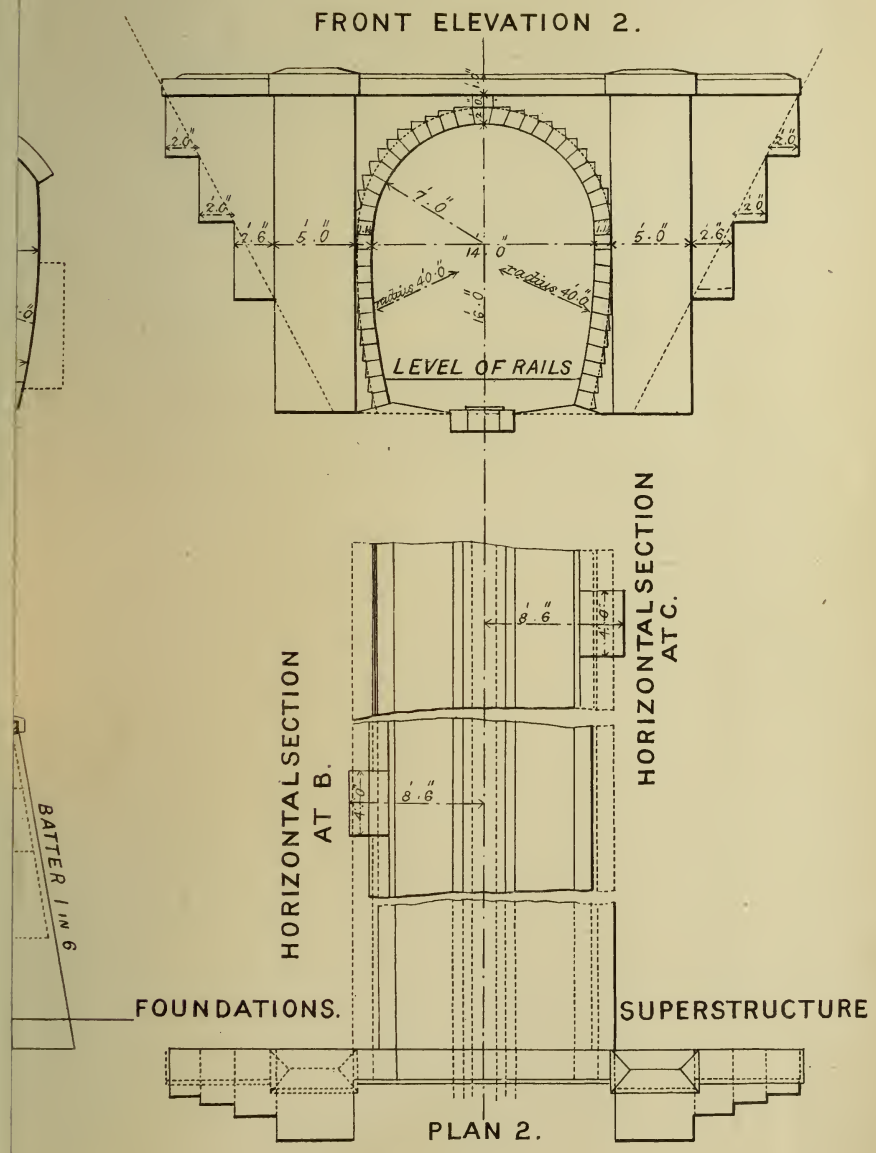
PLAN

Accompanying Mr G.F. Adam's Paper
on the
MAESTEG TUNNEL.

SCALES — { GENERAL SECTION — Horizontal & Vertical 66 Feet to an Inch.
DETAIL SECTIONS — 1/8 of an Inch to a Foot.



[Proceedings S.W.Inst.Engs 1872] No6 Vol II



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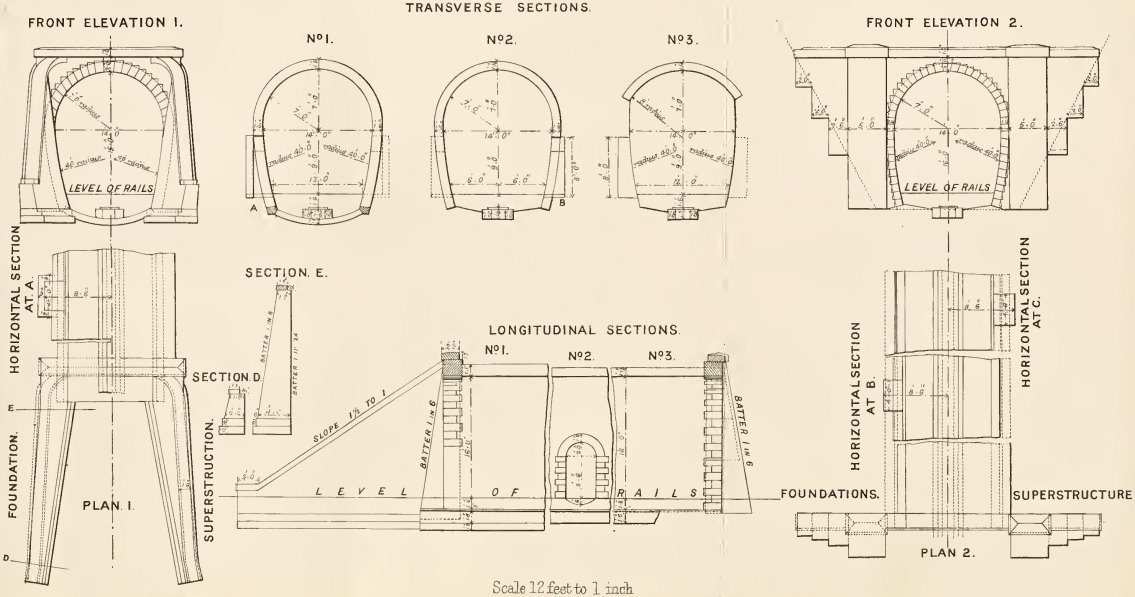
PLAN

Accompanying M^r G. F. Adams' Paper

on the

MAESTEG TUNNEL.



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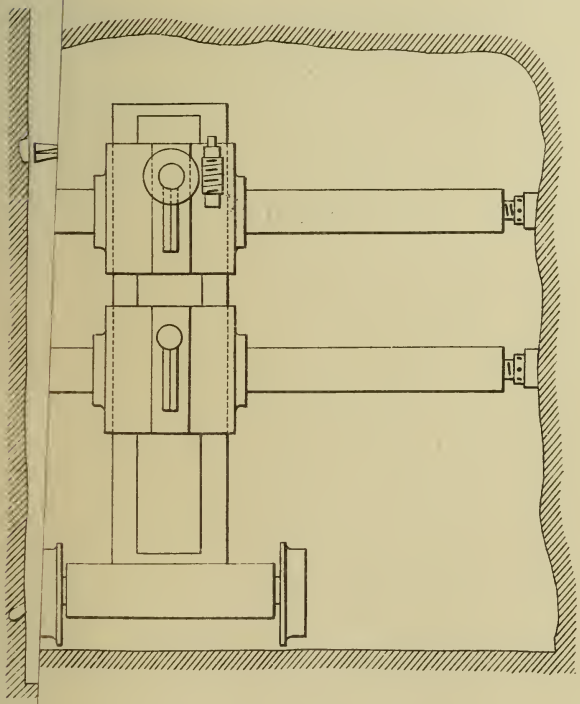
ROSS SECTION THRO HEADING.



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PLAN OF PATENT PERCUSSIVE ROCK DRILL.

Accompanying Mr. G.F. Adams' Paper

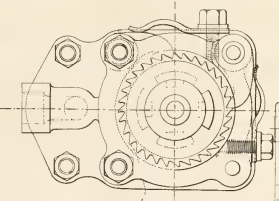
on the

MAESTEG TUNNEL.

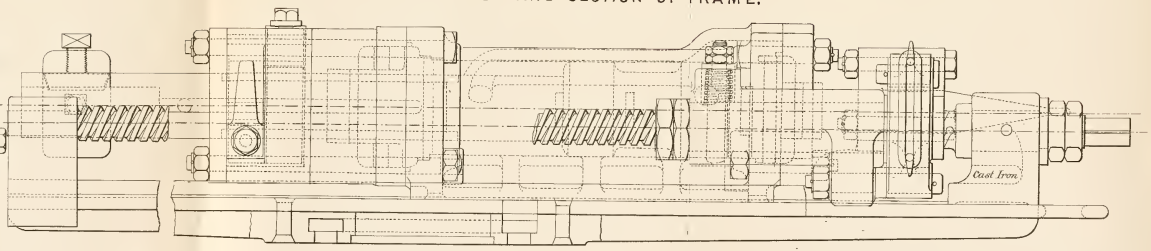
Plate 27.

Scale 3 inches to 1 foot.

END ELEVATION AND SECTION THRO' A.A. OF TWIST MOTION.



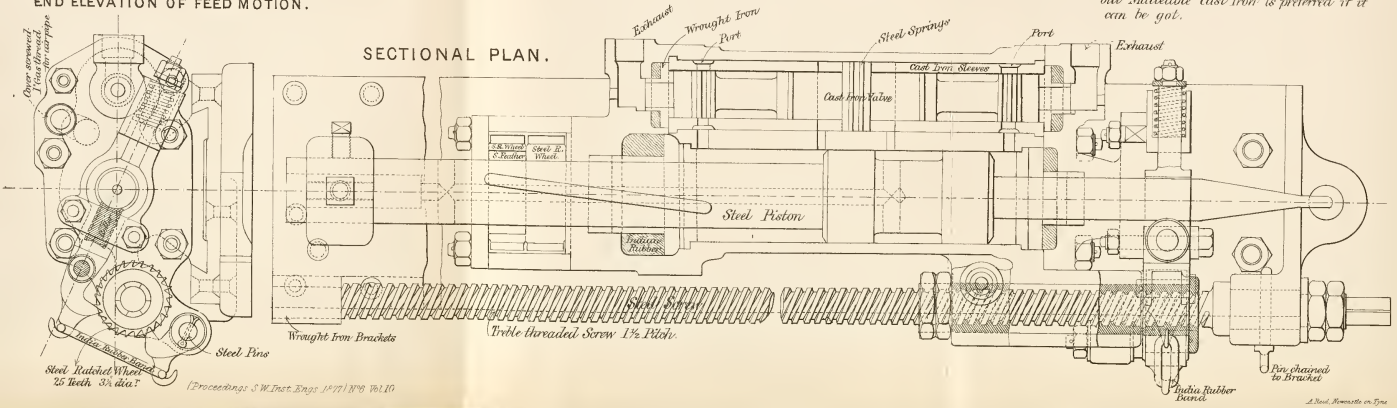
ELEVATION AND SECTION OF FRAME.



N.B. This Drawing shews a Wrought Iron Bed Plate but Malleable Cast Iron is preferred if it can be got.

END ELEVATION OF FEED MOTION.

SECTIONAL PLAN.



(Proceedings S. Wales Inst. Engrs. 1871 No. 8 Vol. 10)

A. Reid, Newcastle on Tyne

OBSERVATIONS ON THE GLYNCORRWG MINERAL DISTRICT FROM THE AVON VALLEY TO THE NEATH TROUGH.

By Mr. Edward Plummer.

The area which is intended to be embraced in this Paper extends from the Avon Valley to the Neath Trough, and the Writer hopes in a second Paper to extend his observations from that trough into the Neath Valley, so as to include, in the whole, an area of over thirty square miles. At the same time he purposes to add a vertical section of the different seams that have been proved in the locality, and to endeavour to correlate the various seams of coal in the Glyncorrwg District with those of the top of the Rhondda on the east and of the Neath Valley on the north.

As the Glyncorrwg District has been developed to such a limited extent and no pits of any great depth have been sunk, there is considerable difficulty in collecting definite information as to the stratification. The only seams that have been worked are those cropping out of the mountain sides, as shown on the plan (Plate 29), and in the horizontal section (Plate 30). The chief reason for the undeveloped state of the district lies in its proximity to the Neath Trough and consequent depth of the lower measures, which, is probably due to the marked change that takes place in the level course of the strata, where, on the left side of the anticlinal (as shown on the plan), the level course makes an angle of about 76° with that on the east side, and from these two lines of level course the strata dips towards the village of Glyncorrwg, forming a deep basin.

The valuable seams of coal which are worked in the Rhondda and Aberdare Valleys lie at a considerable depth, consequent upon the rapid inclination of the seams towards this trough and also to the presence of a minor anticlinal line which runs north of "the Anticlinal Line," as shown on the plan, as well as to two large downthrow faults to the west.

The most valuable seam of coal that is worked in this district is the "Glyncorrwg," which is identical with the "No. 2 Rhondda." It is a semi-bituminous steam coal well adapted for the use of locomotives, being much less bituminous than it is in the Rhondda Valley.

The other seams in the immediate district are identical with the "Forch Dwm" and "Aberdulais" Seams of the Neath Valley.

The "Glyncorrwg" Seam has been proved in a trial pit at Cymmer, at the point marked on the section (Plate 30), and at the north end of the Maesteg Tunnel; it has also been proved in the Avon Valley, about a mile from the upper end, and also by the Great Western Railway Company close to the Blaenavon Farmhouse, where a level was driven on it for about 200 yards, when disturbed ground was met with, and the level course turned round at an angle of 76°, as shown in blue lines on the plan (Plate 29). Higher up the valley the "Glyncorrwg" was again proved by the same Company, an anticlinal line passing between the two openings, the latter of which is situated close to the ridge as marked on plan. This anticlinal line runs across the district, from the Avon Valley, through the Neath Valley, to the north outcrop of the Coalfield, and can be traced at several points in its course. The width of the anticlinal varies from 400 yards to 600 yards, its average inclination being 6 inches in the yard.

The Glyncorrwg Fault, which is a downthrow west of about 80 yards, branches off from the anticlinal on its west side and runs nearly parallel with it for some distance, but gradually diverges towards the south.

There are several other small faults branching off from it

both to the east and west, but in some parts of its course the ground appears to be free of faults, as for instance at Cwm Gwinfi, a branch of the Avon. Near the source of the Gwinfi there is a small brook running towards the east, called Cwm Tarn-y-fran, where the strata can be seen for nearly its whole length and is quite free from any disturbance excepting the ridge, which is plainly visible.

Along the east side of the anticlinal line its ridge is distinctly visible at several points, which are indicated on the plan by the letter R, and a capital section of it may be seen near the source of the Corrwg Fechan Brook.

The dip of the anticlinal line varies from 4 to 8 inches in the yard, and at one or two places it is more.

The Writer is of opinion that the same anticlinal line makes a curve, somewhere near the source of the Avon River, in its course towards the Rhondda Valley; and in corroboration of that view no trace of the anticlinal is to be found in the Ogmore or Garw Valleys, or in the hills between them; and had it existed between the Rhondda and the top of the Ogmore Valleys, it would have been met with in the Ocean collieries at Cwm Park, where the workings have holed through from one valley into the other. In the same way colliery workings have holed through from the Ogmore into the Garw Valley in the "No. 2 Rhondda," without any trace of it having been found.

Another proof is, that at the upper part of both the valleys which lie at about the same elevation (the Tynewydd Station in the Ogmore being 475 feet, and the Pont y Cymmer Station in the Garw Valley being 485 feet above the level of the sea), the level course of the strata is nearly at right angles with the valleys, and the recent winning of the "Two Feet Nine" and the "Six Feet" Seams in the Garw Valley shows that the depth to those seams is less in the latter than in the Ogmore; whereas, if the anticlinal line had passed between the two valleys, the lower measures would have been found at a much greater depth in the Garw than in the Ogmore.

As this anticlinal line is not found in the Ogmore or the Garw Valleys, the only inference, therefore, is that it forms an angle near the upper part of the Avon, and takes its course to the Rhondda Valley, where it is found in several places; maintaining a similar dip, and causing a change of the level course of the strata east and west, as in the Glyncorrwg District.

Its direction through the Rhondda may be traced as follows. It is to be seen at the west side of Tyle-y-Coch Farm-house, and from thence passes down the valley to the Main-dy Farm-house, past the Ystrad Church, Ynis Fach, and the Star Inn. From thence it commences to leave the Rhondda Fawr, and crosses over towards the Rhondda Fach, between Pen-Rhys-Uchaf and Pen-Rhys-Isha Farm-houses, keeping its course across the Rhondda Fach in the direction of the Glôg. It is also to be seen very plainly in the Taff Valley at Felin-y-Gelli, about two miles to the north of Pontypridd. From Felin-y-Gelli it can be traced on the Eglwysillan Mountain; from thence it takes a direction into the Rhymney Valley.

The strata on either side of this anticlinal contains small faults, rolls, and swamps, which are very uncertain in their continuance and occasion much inconvenience in the coal workings within their influence.

From the Writer's experience he is able to state that the great anticlinal line that runs from Pontypridd, across the Ely Valley to Briton Ferry, affects the strata on either side in a very similar manner to that near the synclinal line, or ridge above described.

FAULTS.

The chief faults in the district embraced in this Paper are shown on the plan (Plate 29), and may be shortly described as follows, viz.:—

1. The Pen-y-Castell Fault is a downthrow west of about 150 yards; at the Avon Vale Colliery the "Wenallt Rider" has been

worked from an adit level on the west side of the fault; and in an opposite direction, at Blaen-y-Crigen Adit Level, the same seam has been worked on the east side of the fault; and as the seam crops out on the side of the hill at both collieries, a good opportunity is afforded of pretty nearly determining the size of the fault.

2. A 27-yards downthrow east Fault is to be seen where the two crops of the "Wenallt Seam" and "Riders" are visible, near Glyncorrwg Village, on the side of the parish road that leads to Neath, and the same fault can be traced crossing the Nant-y-Llaethdy, between the Corrwg and the Avon Rivers.

3. A 15-yards downthrow east Fault, which is detected by the difference in the level of the seams which crop out on both sides of the valley.

The last two Faults have probably been the means of bringing to light one of the large seams that crop out at Cefn Mawr on the west side of Pen-y-Castell Fault, and which is worked near the top of the mountain at Glyncorrwg by the Welsh Main Coal Company, and is shown on the horizontal section (Plate 30). Both these seams were worked at a very early date at Cefn Mawr to supply the Melin-y-Court Furnaces.

4. The Glyncorrwg Fault is a downthrow west of about 80 yards, and its course is shown on the plan (Plate 29). It can be plainly seen crossing the Corrwg Fawr River about half a mile to the east of the village; and about half a mile further south it may be seen traversing the district in the direction of the Avon Valley. It crosses the brook about 200 yards north of Abergwinfe Farm-house, and continues south to Bwlch Garw, where it is visible on the west, and can be easily proved by observing the outcrop of the "No. 2 Rhondda" on the east and west sides of it. Mr. Thomas Joseph has an opening on the east side, and the Pwll Carn Coal Company has one on the same seam on the west side, with the fault running between, removing all doubt as to the position of the fault, which is there found to be a downthrow west of about 70 yards.

At Bwlch Garw a remarkably clear section of the fault is presented, whence it takes its course on to Nant-Hir, but greatly diminished in size as it passes to the south. It is the same fault which crosses the Llangeinor Mountain at a point called Cloddau Duon.

On the plan (Plate 29) the Writer has placed the letter S on the lines of the faults where dislocations of the strata affecting the crops of different seams have been noticed.

THE NEATH TROUGH.

The central position of this trough is shown on the plan (Plate 29) as nearly as possible, although in the neighbourhood of the large faults which cross it, it may be difficult to determine the centre in consequence of the strata being so flat for a considerable distance to the north and south of it; as, for example, on the south side of the Hendrigarreg Level, belonging to the Welsh Main Coal Company, the strata appears to be quite flat for about 200 yards before it commences to rise to the south; and another instance is at the Blaen-y-Cwm Level, which is situated on the north side of the trough, and where the strata is found to be nearly flat for about 500 yards before it commences to rise to the north; and this probably arises from the proximity of the Pen-y-Castell Fault.

At Blaen-Cwm-Bach Farm-house the strata rises on both sides and leaves no flat in the trough, whence it follows on to Cefn Morfydd old reservoir, passing parallel with Cwm Cavern and on to the Llantwit Church.

Returning to the east, the centre of the trough may be seen in the Corrwg Fawr River, where it forms a flat of about 70 yards before rising to the north and south. Between the Corrwg Fach and Corrwg Fawr Rivers the trough forms an angle by turning a little to the north, and passing on from the Corrwg River for a few hundred yards, it forms a junction with another trough

at an angle of about 30°, at which point the Neath Trough terminates.

The trough which thus joins the head of the Neath Trough is to be seen on the mountain about three-quarters of a mile to the south of Llyn Fach, and thence continues in the direction of the upper end of the Rhondda Valley, passing the Blaen Rhondda Colliery a few hundred yards to the north-west, and on towards the Rhondda Fach; passing Ferndale Collieries on the north and Blaen Cwmaman (or the top of Cwmaman) to the south, it continues nearly parallel to the Aberdare and Rhondda Valleys, and crosses the Taff Valley near the junction of Aberdare and Merthyr Railway (Taff Vale Section).

The horizontal section (Plate 30) that accompanies this Paper shows the relative position of the different seams of coal that have been proved in the vicinity of Glyncorrwg.

It is to be observed that most of the vertical sections appertaining to this district do not show the angle of the stratification through which the pits have been sunk, and are therefore somewhat misleading, unless the actual dip be taken into consideration. The Writer has taken levellings on the east side of the Garw Valley, from the "Abergorci" to the "No. 3 Seam," and from the "No. 3" to the "No. 2 Seam," and also taken similar levellings on the west side of the valley to the same seams, and found the distance between them to agree very nearly, and to be much the same as it is in the Rhondda Valley, and he has little doubt that a careful comparison of the sections of the Neath Valley and immediate district will bear out the same conclusions, although the stratification in the Glyncorrwg District is much thicker than it is in the Neath Valley.

In his next Paper the Writer proposes to present a vertical section of the seams in the Neath Valley, and endeavour to identify them with those in the Glyncorrwg District, which have been already proved, and in this manner compare and correlate the seams in the two districts.

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PLAN

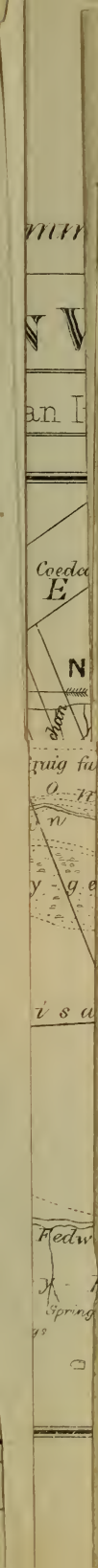
Accompanying Mr. E. Plummer's Paper

on

THE MINERAL DISTRICT FROM THE AVON VALLEY TO THE NEATH TROUGH.

Scale 3/4 Chains to an Inch.

Moel yr Hyrddod
Cefn Rhiwarth
Tyle-mawr
Craig y Fan
Craig y Gelli
Mynydd y Gelli
Cwm Nant y Fedw
Cwm Afon
Cwm Dyrys
Cwm Pen y cae
Cwm Nant Cwm cae
Cwm Nant y Gwair
Cwm Rhys
Cwm Flos Gwrtheche
Cwm Nant Cwm cae
Cefn Nant y Gwair
Cefn Rhiwarth
Bryn Llyn wynddwr
Bryn buch
Bryn Tyle trews
Bryn Bigws
Carn Bryn du die
Carn y wiwer
Nant Llwest
Nant Moel Yorath
Moel Yorath
Mynydd Rhiw Uech
Mynydd Rhiw Gregan
Mynydd Bryn Gwyddelis
Mynydd Llwyn y Fynnon
Mynydd Llwyn Gwyddelis
Mynydd Llwyn Gwyddelis Fault
Mynydd Bryn Gwyddelis Fault
Mynydd Rhiw Uech Fault
Mynydd Rhiw Gregan Fault
Mynydd Bryn Gwyddelis Fault
Mynydd Llwy



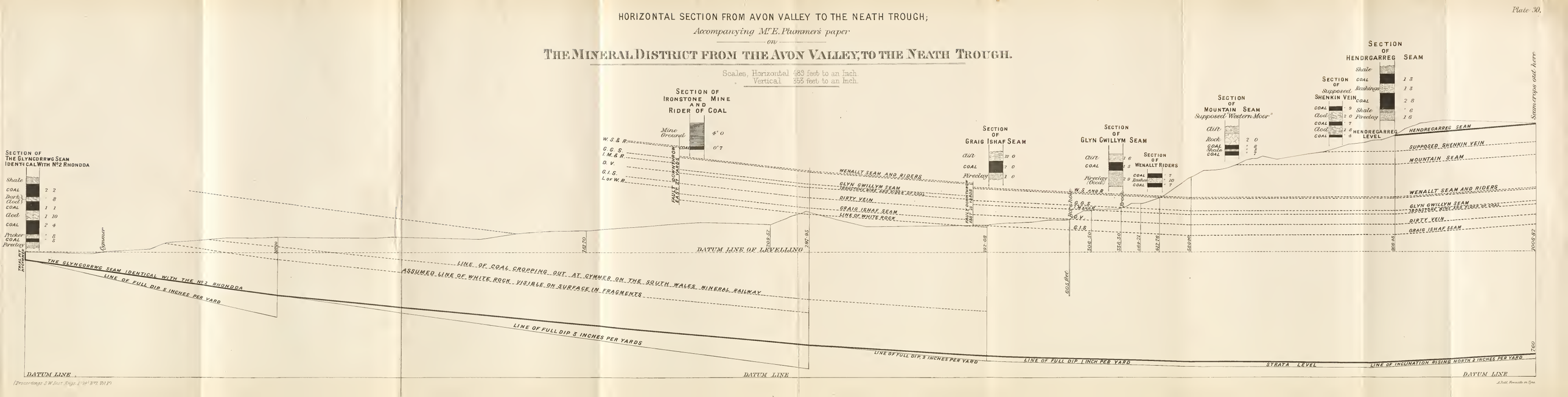
HORIZONTAL SECTION FROM AVON VALLEY TO THE NEATH TROUGH;

Accompanying M.T.E. Plummer's paper

on

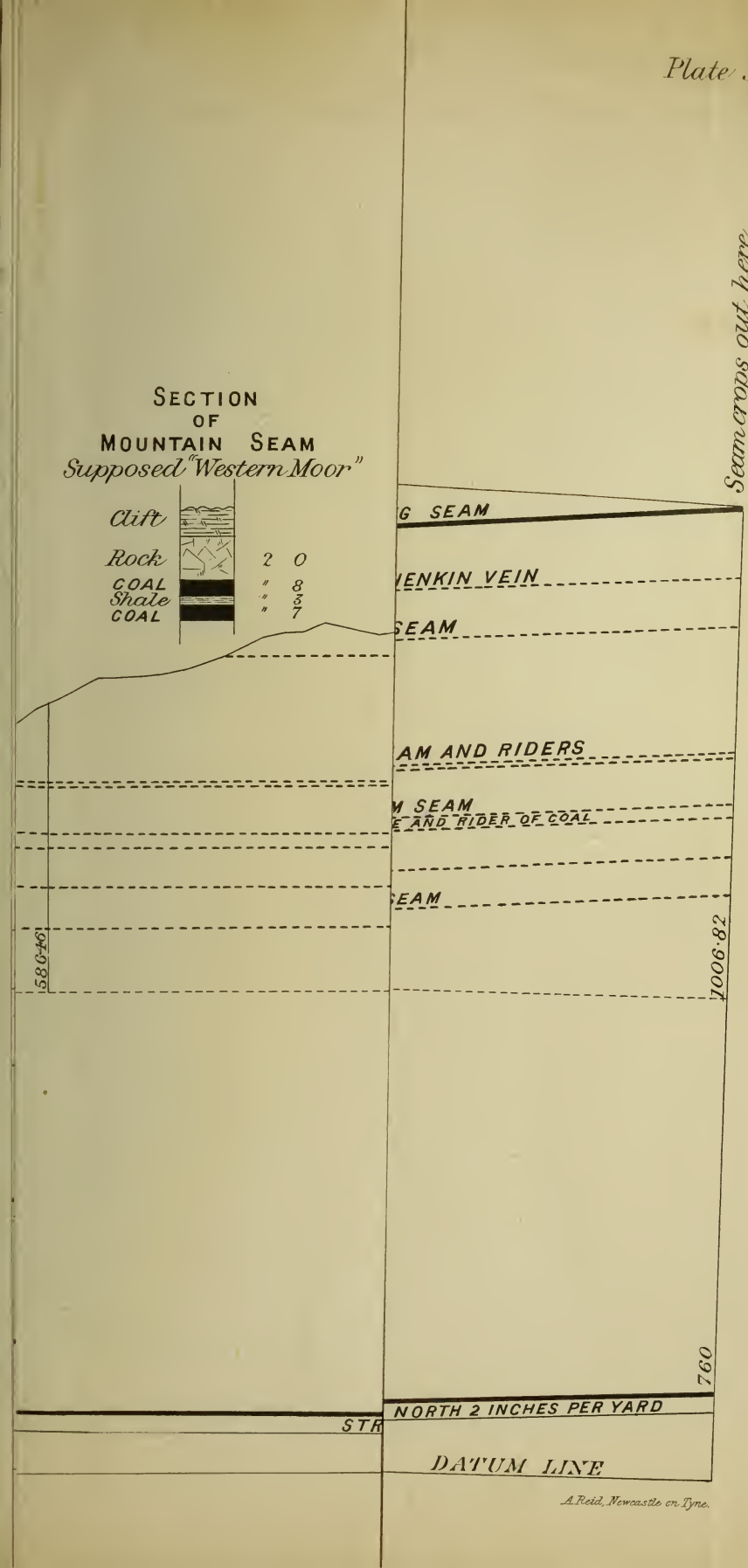
THE MINERAL DISTRICT FROM THE AVON VALLEY, TO THE NEATH TROUGH.

Scales, Horizontal 489 feet to an Inch.
Vertical 353 feet to an Inch.



(Proceedings S.W. Inst. Engs. Vol VII. 1888)

A Bold Mountain in Glen

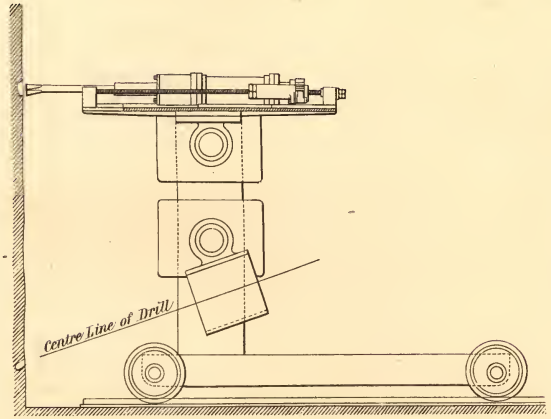

SECTION
OF
MOUNTAIN SEAM
Supposed "Western Moor"
Cliff
Rock 2 0
COAL " 8
Shale " 3
COAL " 7
Seam crops out here
G SEAM
ENKIN VEIN
SEAM
AM AND RIDERS
M SEAM
E AND RIDER OF COAL
EAM
586·46
1006·82
760
NORTH 2 INCHES PER YARD
STR
DATUM LINE
A. Reid, Newcastle on Tyne.

PLAN

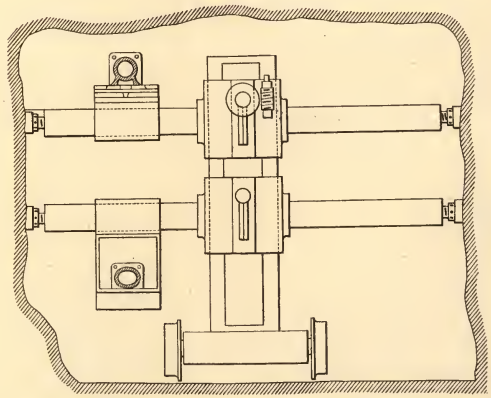
Accompanying Mr. G. F. Adam's Paper
on the
MAESTEG TUNNEL.

Arrangement of Drills on Carriage.

ELEVATION.



END VIEW OR CROSS SECTION THRO HEADING.



Scale ½ Inch to 1 Foot.

A.Reid, Newcastle on Tyne.

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PROCEEDINGS

OF THE

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OF

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